4 ANIMAL KINGDOM

Aristotle (384–322 B.C.) divided animals into two main groups :

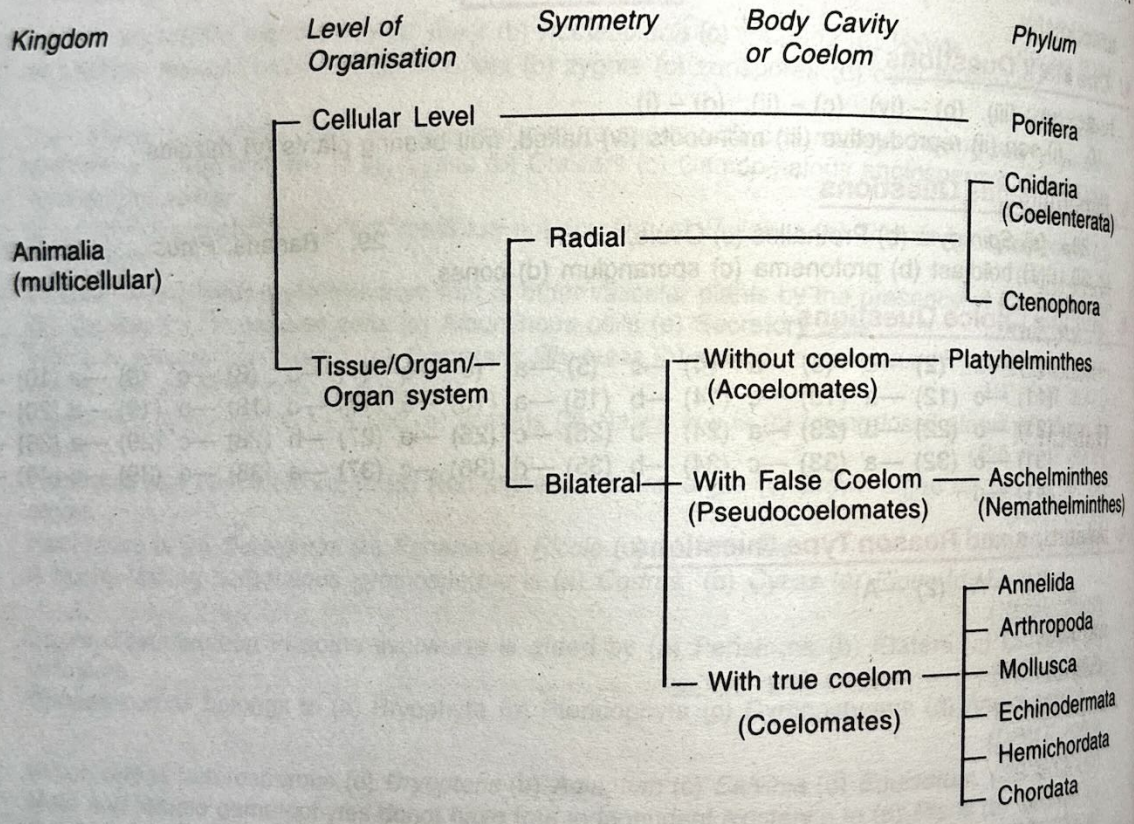
1. **Anaima.** This group includes animals without red blood, *e.g.*, sponges, cnidaria, mollusca, arthropoda, echinodermata, etc.
2. **Enaima.** This group includes animals with red blood, *e.g.*, vertebrates.

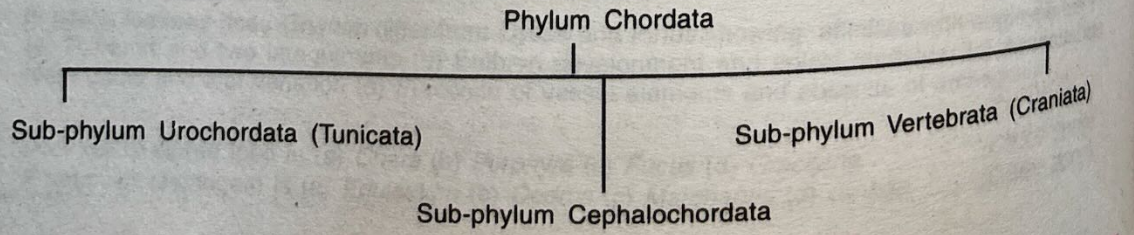
Whittaker's Five Kingdom Classification

R.H. Whittaker (1969), an American taxonomist, divided all the organisms into five kingdoms. As the viruses are on the border line of living and nonliving, they have been left out. Whittaker's five kingdom includes Monera, Protista, Plantae, Fungi and Animalia.

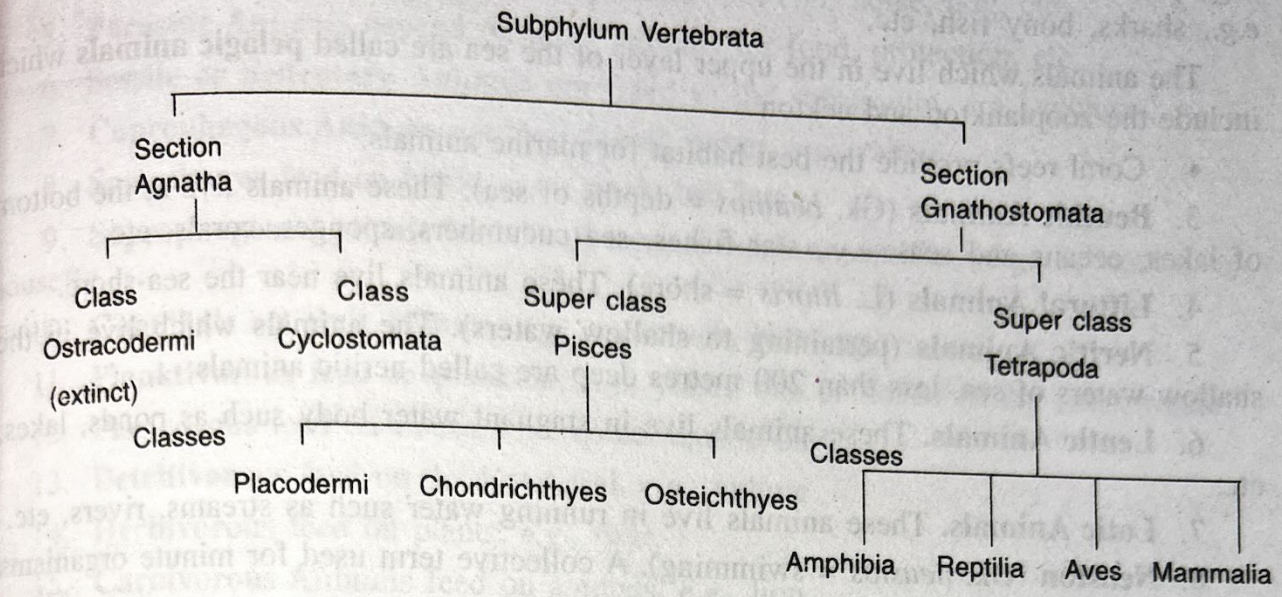
Outline Classification of Kingdom Animalia

A broad classification of animalia based on common fundamental features is given below.





The subphylum Vertebrata is further divided as follows :—



- **Anamniotes.** Vertebrates without embryonic membranes, *e.g.*, fishes, amphibians.
- **Amniotes.** Vertebrates with embryonic membranes (chorion amnion, allantois, yolk sac), *e.g.*, reptiles, birds, mammals.
- **Acrania** or **Protochordata.** Chordates without cranium (brain box). It includes urochordata and cephalochordata.
- **Chordates.** Animals with notochord. All urochordates, cephalochordates and vertebrates are called chordates.
- **Craniata or Vertebrata.** Chordates with cranium. It includes cyclostomes, pisces, amphibians, reptiles, birds and mammals.
- **Nonchordates.** Animals without notochord (a rod like elastic structure which supports the body). Phylum Porifera to phylum Hemichordata are called nonchordates.
- **Invertebrates.** Animals without vertebral column (backbone). All the nonchordates, urochordates and cephalochordates are collectively called invertebrates.

Habitat (L. *habitare* – to inhabit)

The habitat of an organism is the place where it lives. Animals have two major types of habitats, aquatic and terrestrial.

A. Aquatic Animals. They live in water. Animals of sea water are called **marine animals**. Animals of rivers, streams, lakes, ponds and even drains are called **fresh water animals**. Animals which live in between salty and fresh water are called **brackish water animals**.

The aquatic animals are of different kinds.

1. **Zooplankton.** The aggregate of passively floating or drifting animals in a body of water is called zooplankton *e.g.*, many protozoan protists, small crustaceans (arthropods) and various invertebrate larvae.

Nanoplankton (Gk. *nanos* = 'dwarf', a prefix meaning extremely small). These plankton are too small to be caught in a plankton net.

2. **Nekton** (Gk. *nektos* = swimming). The aggregate of actively swimming aquatic

organisms in a body of water able to move independently of water currents is called nekton, *e.g.*, sharks, bony fish, etc.

The animals which live in the upper layer of the sea are called **pelagic animals** which include the zooplankton and nekton.

- Coral reefs provide the best habitat for marine animals.

3. **Benthic Animals** (Gk. *benthos* = depths of sea). These animals live at the bottom of lakes, oceans and seas, *e.g.*, star fishes, sea cucumbers, sponges, corals, etc.
4. **Littoral Animals** (L. *litoris* = shore). These animals live near the sea-shore.
5. **Neritic Animals** (pertaining to shallow waters). The animals which live in the shallow waters of sea, less than 200 metres deep are called neritic animals.
6. **Lentic Animals.** These animals live in stagnant water body such as ponds, lakes, etc.
7. **Lotic Animals.** These animals live in running water such as streams, rivers, etc.
8. **Neuston** (Gk. *neustos* = swimming). A collective term used for minute organisms which rest on the surface of water.
9. **Anadromous fishes.** These marine fishes migrate from the sea into the estuaries for spawning, *e.g.*, *Hilsa*.
10. **Catadromous fishes.** These fishes migrate from estuaries to sea for spawning, *e.g.*, *Anguilla* (eel).
11. **Euryhaline Animals.** These animals have a wide salinity tolerance, *e.g.*, marine animals.
12. **Stenohaline Animals.** These animals have only a narrow range of salinity tolerance and hence remain resticted to either fresh water or salt water.
13. **Sternothermal Animals.** These animals can tolerate a narrow range of variation in temperature, *e.g.*, *trouts* (a type of fishes).
14. **Eurythermal Animals.** These animals tolerate a wide range of variation in temperature, *e.g.*, *Mahseers* (a type of fishes).

B. Terrestrial Animals. They live on land and are of different kinds.

1. **Cursorial Animals.**They run fast, *e.g.*, kangaroo, dog, horse, etc.
2. **Fossorial Animals.** They live in burrows/underground, *e.g.*, earthworm, rabbit, etc.
3. **Arboreal Animals.** They live on the trees, *e.g.*, bats, monkeys, etc.
4. **Scansorial Animals.** They climb walls, rocks, etc., *e.g.*, wall lizard, flying squirrel, etc.
5. **Volant or Aerial or Flying Animals.** They can fly, *e.g.*, winged insects, birds, bats, etc.

Habits

Habit refers to nature of the animals.

1. **Solitary Animals** live alone, *e.g.*, Tapeworm, grasshopper.
2. **Colonial Animals** live in groups and help one another and thus show social life, *e.g.*, honey bees, termites, wasps and ants.
3. **Gregarious Animals** live in groups but, do not help one another, *e.g.*, locust.

*Esturine waters. Waters where big rivers fall into the ocean.

4. **Free Living Animals** lead an independent life, *e.g.,* horse, dog, etc.
5. **Parasitic Animals** depend on other animals for food, protection, etc.
6. **Sessile or Sedentary Animals** are fixed to the substratum, *e.g.,* sponges.
7. **Coprophagous Animals** eat their faecal matter, *e.g.,* rabbit.
8. **Sanguivores** feed on blood, *e.g.,* leech, bed bug.
9. **Saprophagous Animals** feed on all sorts of fluids or semifluid organic matter, *e.g.,* housefly.
10. **Cannibals** eat their fellows, *e.g.,* cockroach, bed bug.
11. **Planktivorous** feed on plankton, *e.g.,* young one of *Labeo* (Rohu fish), whale.
12. **Piscivorous** feed on fishes, *e.g.,* some aquatic birds.
13. **Detritivorous** feed on dead material, *e.g.,* vulture.
14. **Herbivorous** feed on plants, *e.g.,* deer.
15. **Carnivorous Animals** feed on animals, *e.g.,* lion.
16. **Omnivorous Animals** feed on all kind of food, *e.g.,* man.
17. **Larvaevorous Animals** feed on larvae, *e.g.,* *Gambusia* (mosquito fish).
18. **Grainivorous Animals** feed on grains, *e.g.,* pigeon.
19. **Folivorous Animals** eat leaves, *e.g.,* sheep, goats.
20. **Polygamous Animals** live in the company of more than one sexual partner, *e.g.,* deer, zebra, etc. (a) **Polyandrous Animals—** a female mates with more than one males. (b) **Polygynous Animals—** a male mates with more than one female.
21. **Monogamous Animals** have only one sexual parterner.
22. **Monoecious or Hermaphrodite or Bisexual Animals** are the animals in which both male and female sex organs are found in one individual, *e.g.,* Tapeworm, liver fluke, earthworm, leech, etc.
23. **Dioecious or Unisexual Animals** are the animals which have only either male or female sex organs, *e.g.,* most of animals.
24. **Protandrous Animals** are the animals in which male sex organs mature earlier than the female sex organs, *e.g.,* earthworm.
25. **Protogynous Animals** are the animals in which female sex organs mature earlier than male sex organs, *e.g.,* *Herdmania.*
26. **Oviparous Animals** lay eggs, *e.g.,* frog, birds, egg laying mammals.
27. **Ovoviviparous Animals** are the animals which give birth to young ones without placenta formation, *e.g.,* shark, viper.
28. **Viviparous Animals** give birth to the young ones with placenta formation, *e.g.,* rabbit, human beings, etc.
29. **Poikilothermal or Ectothermic or Cold Blooded Animals** are those animals in which body temperature varies according to the surrounding environment, *e.g.,* all invertebrates, fishes, amphibians and reptiles.
30. **Homoiothermal (= Homeothermic) or Endothermic or Warm Blooded Animals** are those animals in which body temperature remains constant and does not change with the change of environmental temperature, *e.g,* birds and mammals.

Esturine Waters. Waters where big rivers fall into the ocean.

Differences between Poikilothermic and Homeothermic Animals

Poikilothermic (Cold blooded) Animals	*Homeothermic (Warm blooded) Animals*
1. Their body temperature changes according to surrounding environment.	1. Their body temperature remains constant and does not change with the change of environmental temperature.
2. These animals are less active. Examples : all invertebrates, fishes, amphibians and reptiles.	2. These animals are more active. Examples : birds and mammals.

Differences between Ovipary and Vivipary

Ovipary	*Vivipary*
1. It is the phenomenon in which animals lay eggs, which develop outside the mother's body and hatch into young-ones.	1. It is the phenomenon in which development occurs inside the mother's body and a young-one is born.
2. The food required for development of embryo is already stored in the egg.	2. The food required for the growth of embryo is provided by the mother through placenta.
3. Ovipary occurs in egg-laying animals (*e.g.*, frogs, crocodiles, birds, egg laying mammals, etc.)	3. Vivipary occurs in metatherians, (*e.g.*, kangaroos) and eutherians (*e.g.*, rabbit, man, etc.)

31. **Nocturnal Animals** like darkness, *e.g.*, Owl.
32. **Diurnal Animals** are active during day, *e.g.*, man, horse, etc.
33. **Crepuscular Animals** move about in twilight, *e.g.*, rabbit.
34. **Frugivorous Animals** feed on fruits, *e.g.*, parrot.
35. **Coprozoic Animals** feed on dung, *e.g.*, pig
36. **Vespertine Animals** are active during evening or dusk, *e.g.*, small insectivorous bats.
37. **Saltatorial Animals** are the animals whose hindlegs are long and modified for jumping, *e.g.*, locust, grasshoppers and crickets.
38. **Auroral Animals** are active during dawn.
39. **Cave Dewellers** live in caves, *e.g.*, Proteus
40. **Epilithic Animals** adhere to rocks or stones.
41. **Epiphytic Animals** get attached to the surface of plants.
42. **Epizoons** are those animals which live on the body of other animals.

Some other habits of animals are as follows.

- **Mimicry**. It is the resemblance of one organism to another or to any natural object for the purpose of concealment, protection or for some other advantage.
- **Crypsis.** It is a type of colouration in which an animal helps to camouflage in its natural environment.
- **Autotomy**. Self mutilation of a part of the body is called autotomy. It is observed in legs of prawn and in tail of wall lizard.
- **Regeneration.** Regeneration involves (1) **Epimorphallaxis** — restoration of lost part and (2) **Morphallaxis**— reconstruction of whole body from a small part of the organism's body.

• **Hibernation. "Winter sleep".** It is observed in frogs, many reptiles, and some mammals during winter season.

• **Aestivation. "Summer sleep".** It is observed in frogs during too much heat.

• **Parthenogenesis.** Development of an egg (ovum) into a complete individual without fertilization by a sperm is known as parthenogenesis. Drones (males) of honey bees are formed by parthenogenesis.

• **Paedogenesis.** When parthenogenesis occurs in larva it is called paedogenesis. It occurs in **sporocyst** and **redia** larvae of liver fluke.

• **Neoteny.** When the larva retains adult characters such as gonads and starts producing young ones by sexual reproduction it is called **neoteny.** It occurs in the **axolotl** (larva of *Ambystoma*— tiger salamander).

Basis of Classification

Although there are differences in structures and forms of different animals, yet there are common fundamental features in various individuals in relation to the arrangement of cells, body symmetry, nature of coelom, patterns of digestive, excretory, circulatory or reproductive system. These features are used as the basis of animal classification.

Levels of Organisation (= Grades of Organisation). Four levels of organization are found in animals.

1. **Protoplasmic or Acellular Level.** The organisation is at the level of protoplasm. It is present in protozoans.

2. **Cellular Level.** The body consists of many cells which may be similar or show minor division of labour *e.g.,* sponges.

3. **Tissue Level.** The cells form poorly defined tissues, *e.g.,* Cnidarians (=coelenterates).

4. **Organ-System Level.** The cells are organised into tissues, tissues into organs and organs into organ systems. Except sponges and coelenterates, all the animals of the kingdom animalia have organ-system level of organisation.

Body Plans. Animals have three types of body plans :

1. **Cell Aggregate Plan.** The body consists of a cluster or aggregation of cells. It is found in sponges.

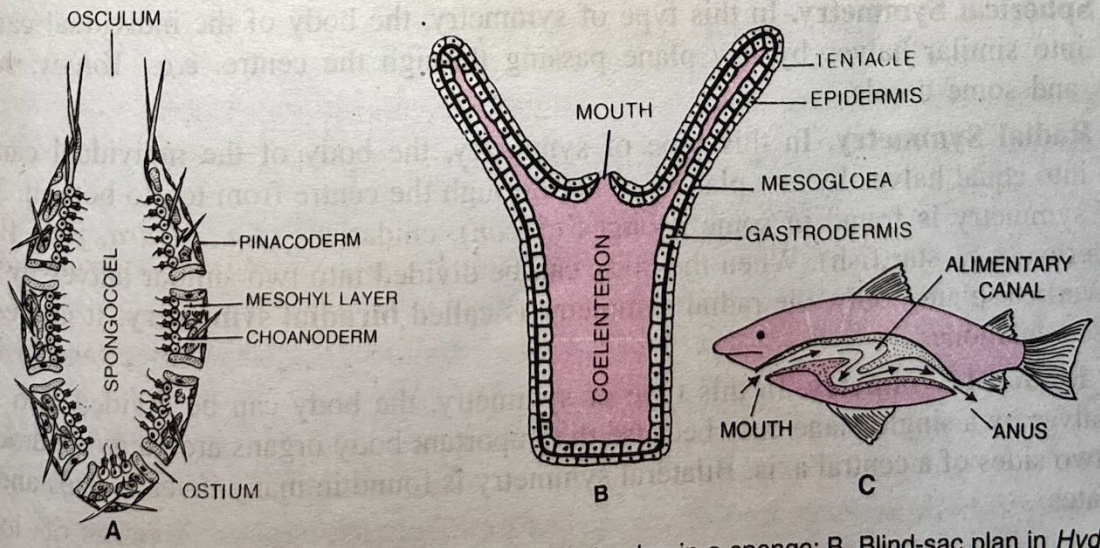


Fig. 4.1. The three basic body plans. A; Cell aggregate plan in a sponge; B, Blind-sac plan in *Hydra*; C, Tube-within-a-tube plan in fish.

2. **Blind Sac Plan**. The body has a single cavity with one opening to the outside. The single opening functions as both mouth for ingestion (intake of food) and anus for egestion (undigested food is passed out). It is found in Cnidarians (=coelenterates) and flatworms.

3. **Tube-within-a-Tube Plan**. The body has two tubes, one formed by the body wall and the second formed within it by the digestive tract. Digestive tract is a continuous tube-like structure that has two openings, a mouth for ingestion and anus for egestion. Food is digested and absorbed in the digestive tract (alimentary canal). Tube-within-a tube plan is of two types :

(i) **Protostomic Plan.** The mouth of the digestive tract develops first in the embryo and anus is formed later. This occurs in roundworms, annelids, molluscs and arthropods. The animals which have this body plan are called **protostomes**.

(ii) **Deuterostomic Plan**. The anus of the digestive tract develops first in the embryo and the mouth is formed later. This is seen in echinoderms and chordates. Thus chordates are evolutionarily closer to the echinoderms. The animals which possess this body plan are called **deuterostomes**.

Differences between Protostomic and Deuterostomic Plans

Character	*Protostomic Plan*	*Deuterostomic Plan*
1. **Cleavage**	*Determinate	*Indeterminate
2. **Development of Mouth and Anus**	Mouth develops first and anus later on in the embryo.	Anus develops first and mouth later on in the embryo.
3. **Coelom**	*Schizocoelom	*Enterocoelom
4. **Examples**	Annelida, Mollusca and Arthropoda	Echinodermata, Hemichordata and Chordata

Body Symmetry. Body symmetry is the similarity of parts in different regions and directions of the body. When the body is not divisible into equal halves by any plane it is called **asymmetrical** or **asymmetric** as found in *Amoeba* and some sponges. An animal is said to be **symmetrical** if its body is divisible into equal halves by one or more planes. Three types of symmetry are usually seen in the animals.

1. **Spherical Symmetry.** In this type of symmetry, the body of the individual can be divided into similar halves by any plane passing through the centre. *e.g.*, *Volvox*, some sponges and some corals.

2. **Radial Symmetry**. In this type of symmetry, the body of the individual can be divided into equal halves by any plane passing through the centre from top to bottom. This type of symmetry is found in some sponges (*Sycon*), cnidarians (*e.g.*, *Hydra*, jelly fish), echinoderms (*e.g.*, star fish). When the body can be divided into two similar halves by one or two vertical planes only, the radial symmetry is called **biradial symmetry**. It is present in the sea anemones.

3. **Bilateral Symmetry.** In this type of symmetry, the body can be divided into two equal halves by a single plane only because the important body organs are paired and occur on the two sides of a central axis. Bilateral symmetry is found in many invertebrates and all vertebrates.

*Explained ahead

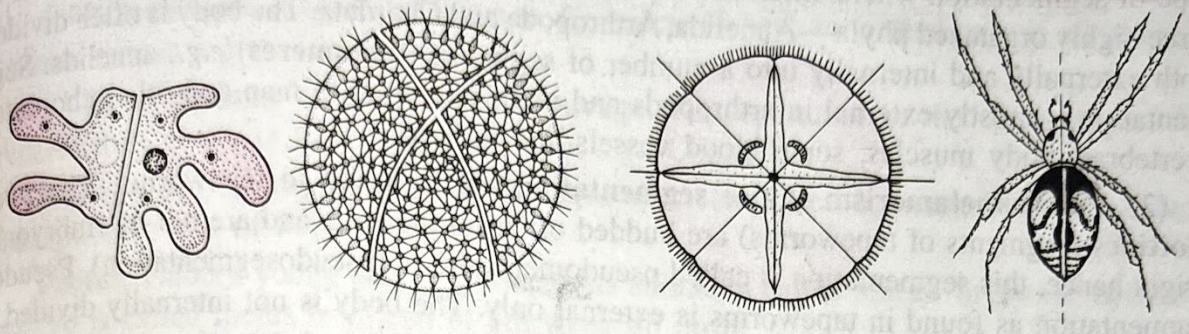


Fig. 4.2. A, Asymmetry in *Amoeba*; B, Spherical symmetry in *Volvox*; C, Radial symmetry in Jelly fish; D, Bilateral symmetry in Spider.

- The right and left sides of the body are called the **lateral sides**. The side of the body which is kept forward during locomotion is termed the **anterior side** and the opposite one is called **posterior side**. The back or upper surface is termed **dorsal** and the under surface (towards the substratum) is called **ventral** (*L.venter*– belly).
- The part of a tissue, organ, etc. that is nearest to the point of attachment or origin is known as **proximal end**. For example, upper arm is proximal end of the forelimb. The part of a tissue, organ, limb, etc. that is farther away from the point of attachment or origin is called **distal end.** For example, the fingers are at the distal end of the fore limb.
- **Anatomical Body Planes**. Animal body can be cut along three planes (transverse, horizontal and vertical) for examining its internal structure. A vertical section passing through the middle line of the body is known as the **saggital section**.

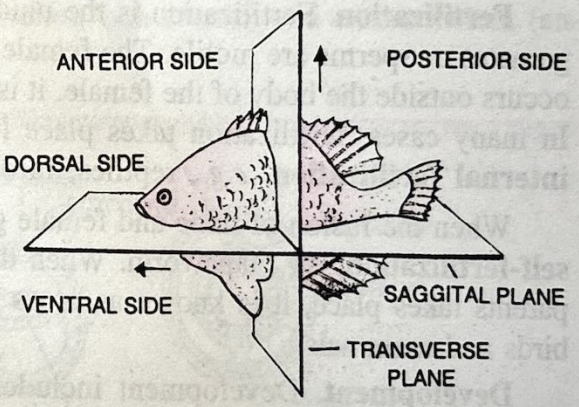


Fig. 4.3. Diagram showing the different sides, planes, etc.

Diploblastic and Triploblastic Animals. The embryos of porifers and cnidarians have two germinal layers, the **ectoderm** and **endoderm**. These animals are called **diploblastic**. An undifferentiated layer, **mesogloea**, is present in between the ectoderm and endoderm. The embryos of all other animals (from phylum Platyhelminthes to phylum Chordata) have three germinal layers— the **ectoderm, mesoderm** and **endoderm.** These animals are called **triploblastic animals**. The germinal layers form the body of the animals.

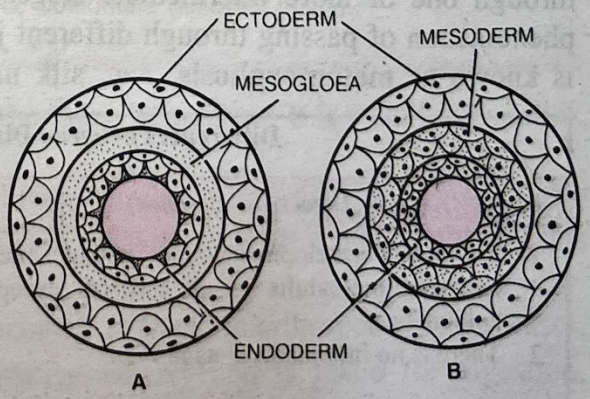


Fig. 4.4. Showing germinal layers : A, Diploblastic ; B, Triploblastic.

Segmentation. Segmentation is division or differentiation of the body into distinct portions called segments. It is of two types: metameric segmentation and pseudo-metamerism.

(1) **Metameric Segmentation (True metamerism or True segmentation).** It is a

type of segmentation where external divisions correspond to internal divisions. It occurs in three highly organized phyla— Annelida, Arthropoda and Chordata. The body is often divided both externally and internally into a number of segments (**metameres**) *e.g.*, annelids. Segmentation is mostly external in arthropods and mainly internal in man and other chordates (vertebrae, body muscles, some blood vessels and nerves).

(2) **Pseudometamerism (False segmentation).** It is found in tapeworms. The **proglottides** (segments of tapeworms) are budded off from the neck and are not of embryonic origin hence, this segmentation is called pseudometamerism (pseudosegmentation). Pseudosegmentation as found in tapeworms is external only. The body is not internally divided.

Cephalization. Differentiation of a definite head at the anterior end is termed the cephalization. There is a concentration of sense organs, nervous tissue (brain) and food catching organs at the anterior end.

Appendages. Projecting parts from the body of an animal that serve in locomotion, feeding and other ways are called appendages. They include tentacles of cnidarians, minute **setae** and **parapodia** of many annelids, **antennae, legs** and **wings** of arthropods, **foot** of molluscs and **fins**, **legs** and **wings** of vertebrates.

Sexual Dimorphism. When the male and female animals can be distinguished externally, the condition is called **sexual dimorphism**. The latter is seen in paeacock and peahen, lion and lioness, and human beings.

Fertilization. Fertilization is the union of male and female gametes. In animals, male gametes or sperms are motile. The female gametes or ova are nonmotile. When fertilization occurs outside the body of the female, it is called **external fertilization,** *e.g.*, Starfish, Frog. In many cases, fertilization takes place in the genital tract of the female. It is known as **internal fertilization**, *e.g.*, reptiles, birds, mammals.

When the fusion of male and female gametes of the same parent takes place it is called **self-fertilization,** *e.g.*, tapeworm. When the fusion of male and female gametes of different parents takes place, it is known as **cross fertilization,** *e.g.*, all fishes, amphibians, reptiles, birds and mammals.

Development. Development includes changes that an organism undergoes from its beginning to maturity. It is of two types, direct and indirect. In **direct development**, the young ones resemble the adults in all respects except colour, size. There is no intermediate stage in direct development, *e.g.*, *Hydra*, earthworm and silver fish (insect). In **indirect development**, the young ones do not resemble the adults. The young ones usually pass through one or more intermediate stages before obtaining the shape of the adults. The phenomenon of passing through different juvenile stages before attaining the form of adult is known as **metamorphosis**, *e.g.*, silk moth.

Differences between Direct and Indirect Development

Direct Development	*Indirect Development*
1. In direct development, the young ones resemble the adults in all respects except colour, size.	1. In Indirect development, the young ones donot resemble the adults.
2. There is no intermediate stage.	2. The young ones usually pass through one or more intermediate stages before obtaining the shape of adults.
3. Examples — *Hydra*, Earthworm, Human Beings.	3. Examples — Silkmoth, Housefly, Frog.

Cleavage. On the basis of potentiality, cleavage is of two types :

1. **Determinate (Mosaic) Cleavage**. Complete embryo is formed only if all the blastomeres remain together, *e.g.*, Annelids.

2. **Indeterminate (Non-mosaic) Cleavage**. On seperation in the early stage, blastomeres may give rise to complete embryo, *e.g.*, Chordates.

Embryo. It is an organism in early stages of development. In human beings it is from conception to end of 8th week.

Foetus. Unborn young one of a viviparous animal is called foetus. In human beings an embryo is called foetus from end of 8th week till birth.

Acoelomates. The animals which do not have coelom are called **acoelomates** *e.g.*, sponges, cnidarians, ctenophores and flat worms.

Pseudocoelomates. The animals which have body cavity, called **pseudocoel,** derived from blastocoel of the embryo are called pseudocoelomates. Round worms are **pseudocoelomates.**

Eucoelomates (Coelomates). The animals which possess true coelom are called eucoelomates or coelomates. *The true* ***coelom*** *is a body cavity which arises as a cavity in embryonic mesoderm.* In this case, the mesoderm of the embryo provides a cellular lining, called **coelomic epithelium** or **peritoneum**, to the cavity. The coelom is filled with **coelomic fluid** secreted by the peritoneum. True coelum is found in annelids, echinoderms and chordates. True coelom is of two types; schizocoelom (schizocoel) and enterocoelom (enterocoel).

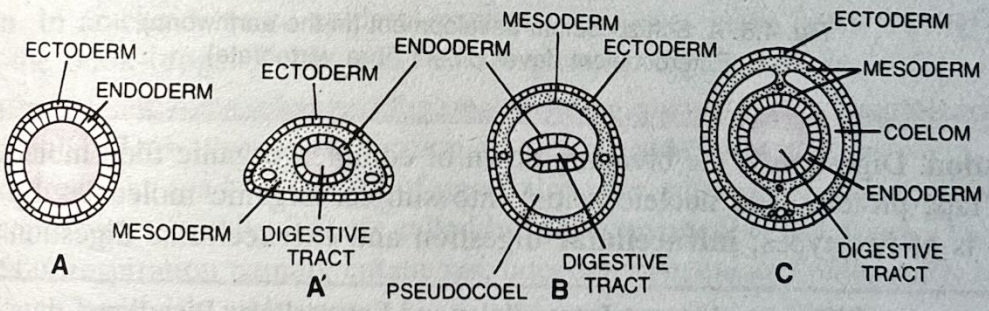


Fig. 4.5. Body cavity or coelom. Cross-sectional diagrams of the three main types of animals based on the absence or presence and type of body cavity or coelom. A and A′, Acoelomates; A— without mesoderm (sponge and coelenterate) A′.; —with mesoderm (flatworm); B, Pseudocoelomate (roundworm); C, Coelomate (all other phyla).

1. **Schizocoelom.** It develops as a split in the mesoderm sheet. It is found in annelids, arthropods, molluscs.

2. **Enterocoelom**. The mesoderm arises from the wall of the embryonic gut or enteron as hollow outgrowths which form this type of coelom. It occurs in echinoderms and chordates.

The cavity filled with blood is called **haemocoel**. It is found in arthropods and molluscs.

Digestive Tract. Digestive tract is the passage where food is taken for digestion, absorption and elimination of undigested food. Cnidarians and flat-worms have a digestive tract with a single opening termed **mouth** that takes food as well as eliminates the undigested food. This type of digestive tract is called **incomplete**. Digestive tract of many animals has

two openings; mouth for intake of food and anus for the elimination of faecal matter. Such a digestive tract is termed **complete**. It is found from round worms to mammals.

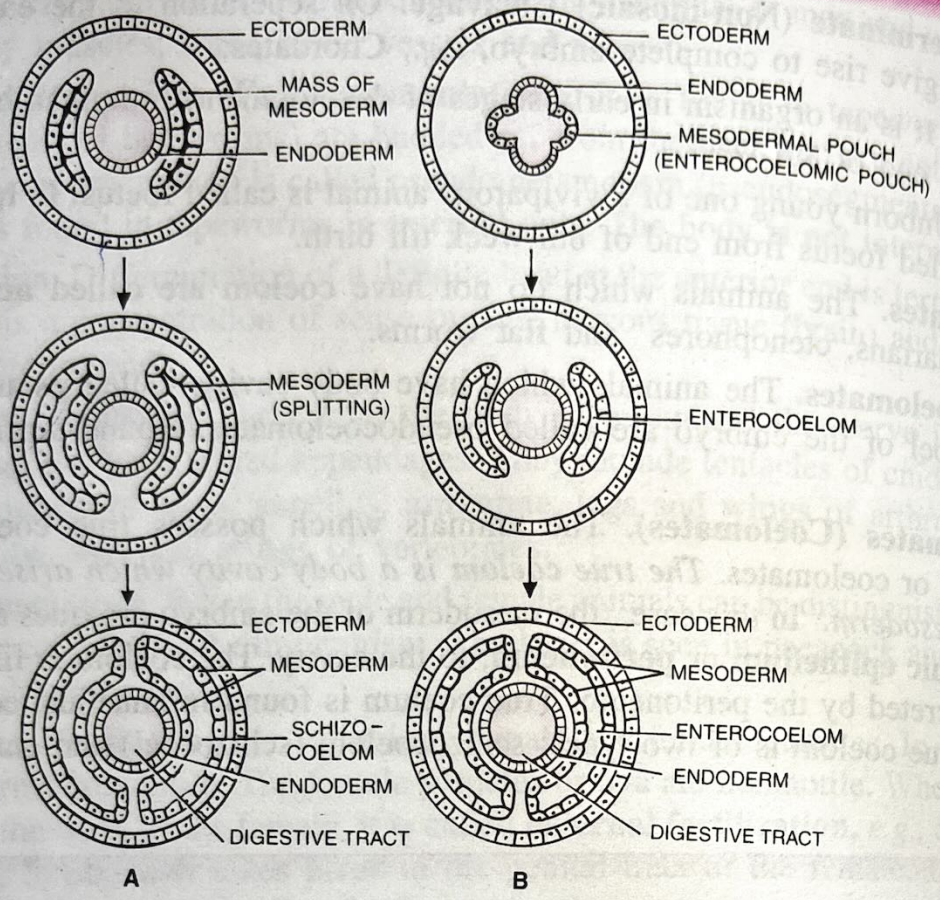


Fig. 4.6. A, Schizocoelom development (in the earthworm); B, Enterocoelom development (in a vertebrate).

Digestion. Digestion is the breaking down of complex organic food molecules (carbohydrates, fats, proteins and nucleic acids) into simpler organic molecules by hydrolysis. Digestion is of two types; **intracellular** digestion and **extracellular** digestion.

Differences between Intracellular and Extracellular Digestion

Intracellular Digestion	*Extracellular Digestion*
1. It occurs within the cells.	1. It occurs outside the cell in a cavity.
2. Digestive enzymes are poured into the food vacuoles where digestion of food takes place.	2. The digestive enzymes are poured into the cavity, where digestion of food takes place.
3. The products of digestion diffuse into the cytoplasm.	3. The products of digestion diffuse into the wall of the cavity.
4. It occurs in protozoans and sponges.	4. It occurs in higher invertebrates and all vertebrates.

- Cnidarians, flat worms and protochordates carry on both intracellular and extracellular digestion.

Heterotrophic Mode of Nutrition. In this type of nutrition the organisms take energy by digesting food which has been manufactured by other organisms. Thus all organisms perform heterotrophic mode of nutrition except autotrophs (which manufacture their own food through photosynthesis, *e.g.*, plants).

Types of Heterotrophs (i) **Herbivores**— eat plants (ii) **Carnivores**— eat animals (iii) **Omnivores**— eat both animals and plants.

Active Movement. As compared to members of other kingdoms, animals perform more rapid and complex way of movement. Movement of animals is due to the flexibility of their cells, which is perhaps the most characteristic feature of the animals. Some animals can swim (*e.g.*, jelly fish, squids, fishes, whales, etc), some can fly (*e.g.*, butterflies, birds, bats) and others can run or walk on land (*e.g.*, horses, cattle, tigers, lions, men, etc.)

Blood Vascular System. It is a system that takes part in continuous flow of blood in the body. Blood is not present in porifera, cnidaria, ctenophora, platyhelminthes and aschelminthes (nemathelminthes). Blood vascular system is of two types, closed and open. (i) In **closed type**, the blood circulates inside the blood vessels without ever coming in direct contact with the body cells, *e.g.*, annelids, chordates. (ii) In **open type** the blood flows in open spaces like **lacunae** and **sinuses**. It bathes the cells directly, *e.g.*, arthropods, molluscs. Blood may be colourless (*e.g.*, insects), bluish due to a respiratory pigment, the **haemocyanin** (*e.g.*, prawn, pila) or red due to respiratory pigment, the **haemoglobin** (*e.g.*, earthworm, vertebrates).

Respiration (**Exchange of Gases**). **Aerobic animals** utilize oxygen which is obtained from air or water. Certain aquatic animals like *Hydra* take oxygen and give up carbon dioxide through body surface. This is termed **body-surface respiration**. Many animals such as prawn, unio, fish have **gills** for exchange of gases. This type of respiration is called **branchial respiration**. In earthworm, leech, frog, etc., exchange of gases takes place through skin, this is termed as **cutaneous respiration**. In insects and other arthropods, there are present tubular structures, the **tracheae** for exchange of gases, this is called **tracheal respiration**. In arachnids (*e.g.*, spiders) exchange of gases takes place through book-like structures, the **book-lungs**. **Book gills** are respiratory organs in king crabs.

Lungs are meant for exchange of gases in many animals (*e.g.*, amphibians, reptiles, birds, mammals). This type of respiration is termed **pulmonary respiration**. In certain animals like frogs and toads exchange of gases also takes place through the epithelial lining of the buccopharyngeal cavity. This is called **buccopharyngeal respiration.** The frogs have three modes of respiration namely cutaneous, buccopharyngeal and pulmonary. Lung fishes respire through both gills and lungs.

Anaerobic respiration (in absence of oxygen) occurs in various parasitic animals.

Excretion. Excretion is the removal of the metabolic wastes from the body. Sponges, cnidarians, ctenophores and echinoderms lose metabolic wastes by diffusion through body surface. Many animals have definite excretory structures. The flat worms have **flame cells** as excretory structures. In *Ascaris* (round worm), 'H' shaped excretory system of canals and complicated "giant cell" called **renette cell** is present. Annelids have **nephridia** as excretory organs and crustaceans such as prawn contain **antennary (green) glands** in the antennae as excretory organs. Insects and some other arthropods have **Malpighian tubules** as excretory organs. Molluscs and vertebrates have **kidneys** as excretory organs. Excretory organs not only remove metabolic wastes but also maintain water and salt content in the body (**osmoregulation**).

Animals are also classified on the basis of the removal of nitrogenous wastes.

1. **Ammonotelic Animals**. They excrete ammonia. Examples: protozoans (*e.g.*, *Amoeba, Paramecium*), sponges (*e.g.*, *Sycon*), cnidarians or coelenterates (*e.g.*, *Hydra*), Liver fluke, Tape worm, *Ascaris, Nereis,* Earthworm, Leech, Prawn, *Pila,* Bony fish (*e.g.*, *Labeo*), Amphibian tadpoles, tailed amphibians (*e.g.*, Salamanders), Crocodiles.

2. **Ureotelic Animals**. They excrete urea. *Examples:* Cartilaginous fishes (*e.g.*, Sharks and Rays), semi-aquatic amphibians (*e.g.*, frogs and toads), turtles, alligators, mammals including man. *Ascaris* and Earthworm are both ammonotelic and ureotelic.

3. **Uricotelic Animals**. They excrete uric acid. Examples: Most insects, some land crustaceans (*e.g.*, *Oniscus*– commonly known as wood louse), land snails (*e.g.*, *Helix*– commonly called "land snail"), land reptiles (lizards and snakes), birds.

4. **Aminotelic Animals**. They excrete excess amino acids. Examples: Some molluscs (*e.g.*, *Limnaea, Unio*), some echinoderms (*e.g.*, *Asterias*— star fish).

5. **Guanotelic Animals**. They excrete guanine. Example : *Spider.*

Neural System. Neural system is a system of **neurons** (nerve cells) that take part in conduction of impulses and coordination of body activities. Sponges do not possess nerve cells. Cnidarians have network of nerve cells that form "primitive type" of neural system. In flat worms and round worms the neural system consists of nerve ring around the anterior part of the alimentary canal and many nerve cords. In annelids and arthropods it comprises a nerve ring around the anterior part of the alimentary canal and a double ventral solid nerve cord containing **ganglia**. In molluscs, the neural system consists of ganglia, commissures and connectives. A commissure joins two similar ganglia. A connective connects two different ganglia. In echinoderms there are usually present oral and aboral nerve rings and radial nerves. Chordates have dorsally placed hollow nerve cord. In vertebrates the neural system consists of three parts; central neural system, peripheral neural system and autonomic neural system. The **central neural system** comprises the **brain** and **spinal cord**. The brain is situated in the **cranium** (brain box) of the skull and the spinal cord lies in the **neural canal** of the vertebral column (back bone). The nerves which arise from the central neural system constitute the **peripheral neural system**. The latter includes the **cranial nerves** arising from the brain and the **spinal nerves** originating from the spinal cord. The **autonomic neural system** comprises the **sympathetic** and **parasympathetic neural systems**.

Receptors. A receptor is a sensory cell or organ which receives **stimuli** (changes in the environment) from outside or inside the animal and passes impulses to the neural system. The receptors are always connected with the central neural system by means of sensory nerve fibres. Different types of receptors such as eyes, ear, skin etc. are found in various animals.

Endocrine glands. These glands are also called **ductless glands**. Their secretions are known as **hormones**. The latter are mostly transported by blood from the endocrine glands to the **target** cells or **organs** for their physiological activity.

Skeleton. Hard external or internal structures of animal body constitute the **skeleton**. Skeleton supports and protects soft parts of the body. It is of two types; **exoskeleton** and **endoskeleton**. Exoskeleton lies outside the body of an animal and made up of nonliving materials. Examples of exoskeleton are **chitinous cuticle** of arthropods, **calcareous shell** of molluscs, and **scales, feathers, hair, horns, hoofs, claws, nails** and **hair** of vertebrates. Endoskeleton lies entirely within the body of the animal. In vertebrates, it is composed of living hard connective tissues, namely **cartilages** and **bones**. In invertebrates such as sponges it is made up of calcareous and siliceous **spicules**. In some echinoderms (*e.g.*, star fish) calcareous plates, the **ossicles**, which form the endoskeleton, are found in the dermis of the body wall.

Notochord. It is a solid flexible rod like structure found in all chordates. It is derived from the mesoderm.

Differences between Exoskeleton and Endoskeleton

Exoskeleton	*Endoskeleton*
1. It is present outside the body. 2. It is formed from ectoderm or mesoderm. 3. **Examples :** Shell of molluscs and scales, feathers, hair, etc. of vertebrates.	1. It is present inside the body. 2. It is formed from mesoderm or endoderm. 3. **Examples :** Cartilages and Bones of vertebrates and spicules of sponges.

ADDITIONAL INFORMATION

- The term "**Phylum**" was coined by Georges Leopold Cuvier (1829).
- Second largest phylum is Mollusca.
- Largest phylum of animal kingdom is Arthropoda.
- Largest class is Insecta.
- Phylum Ctenophora and Phylum Echinodermata are of exclusively marine animals.
- The term "**Class**" was coined by Linnaeus (1735).
- Terms "**Family**", "**Genus**" and "**Species**" were used first by John Ray (1693).
- **Karyotaxonomy** is based on number of chromosomes.
- **Schenk** and **McMaster** (1958) gave catalogue of international rules for nomenclature.
-

Names of Books	*Authors*
Historia Animalium	Aristotle
Systema Naturae	Linnaeus
Historia Naturalis	Pliny
Historia Naturelle	Georges Buffon

- **Biological species concept** was introduced by **Ernst Mayr** (1942).
- The term '**New systematics**' was proposed by **Sir Julian Huxley** (1940).
- Takhtajan says "Taxonomy without phylogeny is similar to bone without flesh". Phylogenetic classification is based on common evolutionary descent. Modern method of classification is called **cladistics** and is based on evolutionary history.
- **Lotsy** (1918) gave **genetic species concept**.
- Basic unit of classification or taxonomy is species.
- **Binomial nomenclature** was introduced by **Carolus Linnaeus**. He is regarded as 'Father of Taxonomy'.

Phylum Porifera— The Sponges (Pore Bearing Animals)

(Gk. *Porus*– Pore; *ferre*– To bear)

John Ellis (1765) first recognised sponges as animals. **Robert Grant** (1825) finally proved animal nature of sponges and gave the name "**Porifera**". About 5000 species of sponges are known.

General Characters

1. **Habitat**. All sponges are aquatic, mostly marine, rarely fresh water (*e.g.*, *Spongilla*), solitary or colonial, sessile (attached to the substratum). Sponges like warmer water. They are not usually found in cold water.

2. **Body Form**. Their body is porous, *viz.*, provided with pores. The pores are of two types: inhalent pores are called **ostia** (sing. **ostium**) and exhalent pores are known as **oscula** (sing. **osculum**; Fig. 4.7).

3. **Symmetry.** Most of the sponges are asymmetrical. Some are radially symmetrical.

4. **Germ Layers**. The sponges are the first multicellular **diploblastic animals**, *i.e.*, derived only from two embryonic germ layers, *viz.*, **ectoderm** and **endoderm**.

5. **Level of Organization**. The sponges have **cellular level of organization**.

6. **Body wall**. The body wall of a common sponge consists of three layers.

(a) **Pinacoderm (= dermal layer).** It is outer cellular layer which consists of (i) flattened **pinacocytes** and (ii) oval **porocytes** (Fig. 4.7 & 4.8).

(b) **Choanoderm (= gastral layer).** It is inner cellular layer which consists of highly specialized flagellated cells called **choanocytes** or **collar cells** (Fig. 4.7 & 4.8).

Both pinacoderm and choanoderm do not have basement membrane.

(c) **Mesohyl layer (= mesenchyme).** Basically, it is a noncellular layer found in between pinacoderm and choanoderm. It has fine dispersed spongin fibres and numerous spicules (Fig. 4.7). It also contains **amoebocytes** (amoeba-like cells) of both pinacoderm and choanoderm. Amoebocytes are modified into following cells (Fig. 4.8). (i) **Archaeocytes** may be converted into other types of cells and are also called undifferentiated **"totipotent" cells**. (ii) **Trophocytes** provide food to developing cells and are called **nurse cells**. (iii) **Thesocytes** store food granules. (iv) **Gland cells** secrete a slimy substance. (v) **Collencytes** secrete spongin fibres of the mesohyl layer. (vi) **Scleroblasts** secrete spicules. In calcareous sponges, they are called **calcoblasts**. (vii) **Myocytes** form a circular ring around the osculum and help in closing and opening of the osculum. (viii) **Germ cells (Sex cells)** form sperms and ova and develop during breeding season. (ix) **Chromocytes** contain pigment granules and excretory substance. (x) **Phagocytes** collect food from choanocytes through their pseudopodia and also engulf excreta and damaged tissues.

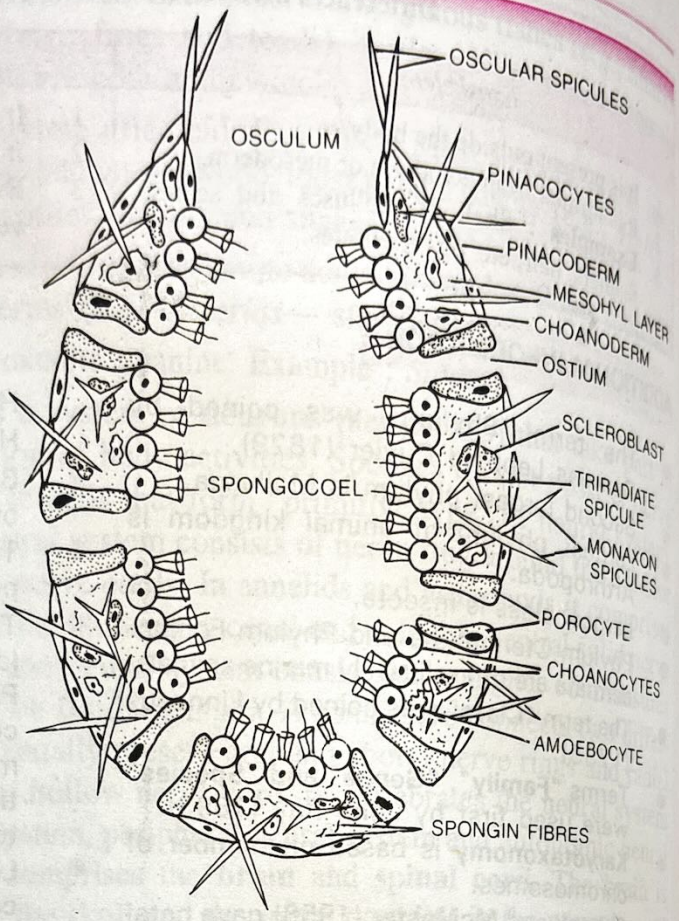


Fig. 4.7. Longitudinal section of a simple sponge.

7. **Canal System.** This system consists of pores and canals. Three types of canal systems (Fig 4.12) are found in sponges: (i) **Asconoid canal system**. It is the simplest type which is found in *Leucosolenia* and a few other sponges. (ii) **Syconoid canal system**. It is more complex than the ascon type. It is found in *Sycon* and some other sponges. (iii) **Leuconoid canal system**. It is most complex canal system which is found in *Spongilla* and some other sponges. In class Demospongiae the leuconoid condition is derived from a larval stage, called the **rhagon**. The canal system of rhagon larva does not occur in any adult sponge. Because of its derivation from rhagon stage in Demospongiae, the leucon type of canal system is also called the **rhagon type**.

The central body cavity of a sponge is called **spongocoel** or **paragastric cavity**.

The continuous water current flowing through the canal system is very important for the life of a sponge. It brings in food and oxygen and carries away carbon dioxide, excretory matter and reproductive bodies. Thus the canal system helps the sponge in nutrition, respiration, excretion and reproduction.

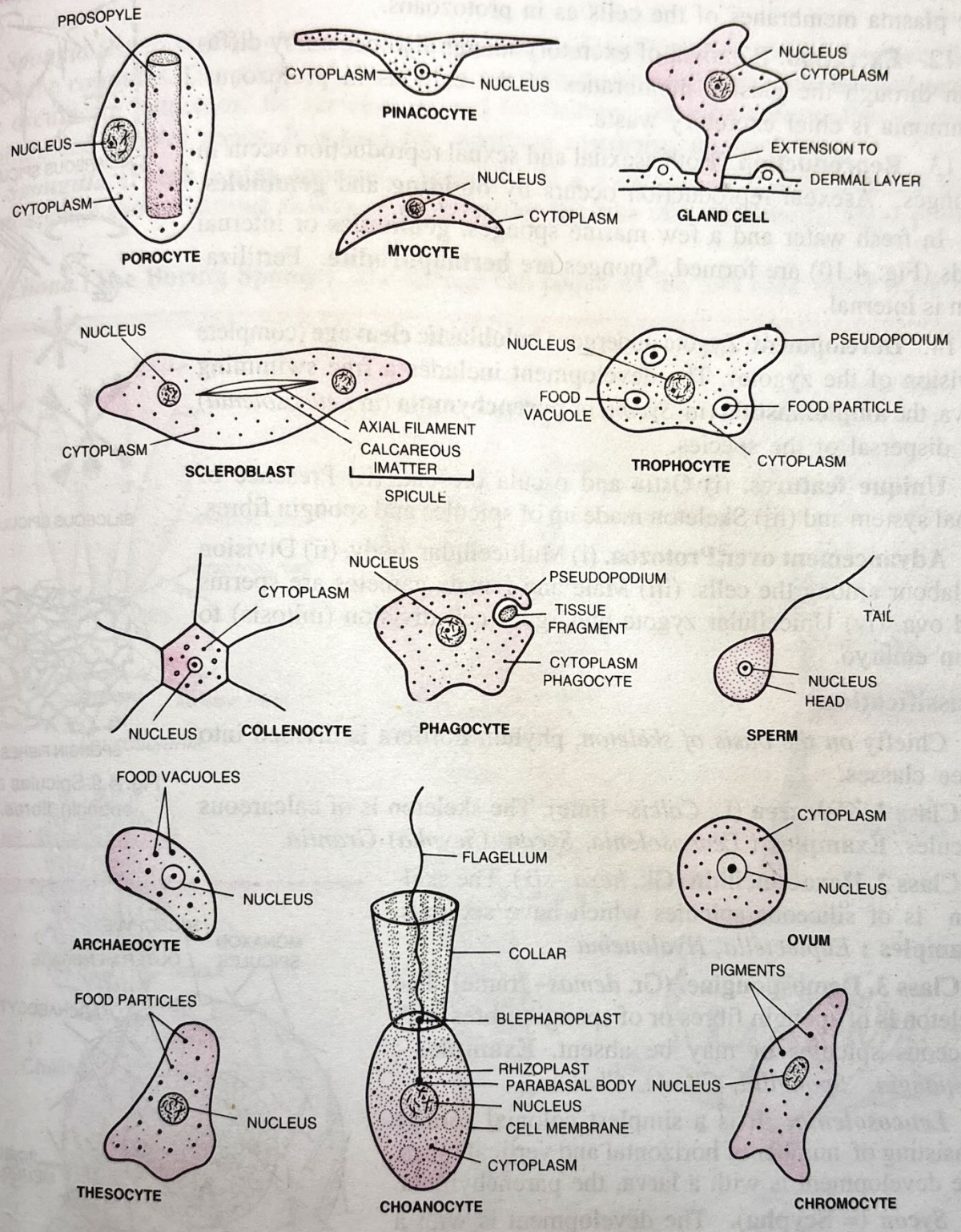


Fig. 4.8. Types of sponge cells.

8. **Skeleton** (Fig. 4.7& 4.9). Almost all sponges possess an internal skeleton. It may consist of calcareous or siliceous **spicules** or of fine **spongin fibres** or of both, located in the mesohyl layer.

9. **Digestion**. It is **intracellular** and takes place inside food vacuoles as in protozoans.

10. **Circulation**. Distribution of food from the ingesting cells to others is brought about by wandering amoebocytes of mesohyl layer.

11. **Respiration**. Exchange of gases occurs by diffusion through the plasma membranes of the cells as in protozoans.

12. **Excretion**. Removal of excretory matter also occurs by diffusion through the plasma membranes of the cells as in protozoans. Ammonia is chief excretory waste.

13. **Reproduction**. Both asexual and sexual reproduction occur in sponges. Asexual reproduction occurs by **budding** and **gemmules**.

In fresh water and a few marine sponges, **gemmules** or internal buds (Fig. 4.10) are formed. Sponges are **hermaphrodite**. Fertilization is internal.

14. **Development**. Zygote undergoes **holoblastic cleavage** (complete division of the zygote). The development includes a free swimming larva, the **amphiblastula** (in *Sycon*) or **parenchymula** (in *Leucosolenia*) for dispersal of the species.

Unique features. (i) Ostia and oscula present. (ii) Presence of canal system and (iii) Skeleton made up of spicules and spongin fibres.

Advancement over Protozoa. (i) Multicellular body. (ii) Division of labour among the cells. (iii) Male and female gametes are sperms and ova. (iv) Unicellular zygote undergoes cell division (mitosis) to form embryo.

Fig. 4.9 Spicules and spongin fibres.

Classification

Chiefly *on the basis of skeleton*, phylum Porifera is divided into three classes.

Class 1. Calcarea (L. *Calcis*– lime). The skeleton is of calcareous spicules. **Examples :** *Leucosolenia, Sycon,* (*Scypha*) *Grantia.*

Class 2. Hexactinellida (Gk. *hexa*– *six*). The skeleton is of siliceous spicules which have six rays. **Examples :** *Euplectella, Hyalonema*

Class 3. Demospongiae. (Gr. *demas*– frame). The skeleton is of spongin fibres or of spongin fibres with siliceous spicules or may be absent. **Examples** : *Euspongia, Spongilla, Cliona, Chalina.*

Leucosolenia. It is a simplest colonial sponge consisting of number of horizontal and vertical tubes. The development is with a larva, the parenchymula.

***Sycon* (= Scypha).** The development is with a larva, the amphiblastula.

***Euplectella* (The Venus' flower basket).** It is found in deep sea water. They are abundant near the Phillipine Island and West Indies. *Its skeleton is costly marriage gift in Japan* as it is thought to be a symbol of union of wife and husband.

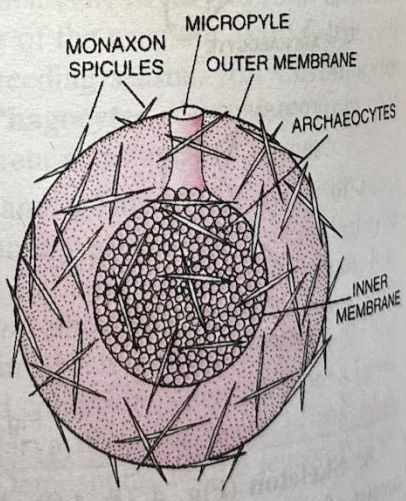


Fig. 4.10. A gemmule.

***Hyalonema*— The glass rope sponge**. Hyalonema is fixed in the mud by a root tuft of long, twisted spicules. The upper surface has the **gastral cone** which bears opening of the excurrent canals. The middle part of the root tuft commonly bears several polyps of

symbiotic anemones of the genus *Epizoanthus* or *Polythoa* which show symbiotic relationship.

***Spongia* (Euspongia)— The bath sponge.** The surface is raised into small projections, called the **connules**. Depressions between the connules bear small pores, the **dermal ostea**. The **oscula** are numerous. Its skeleton is used for bathing, washing automobiles, cleaning furniture and window panes. It is used for applying cosmetics, mopping, etc.

***Spongilla* (Fresh water sponge).** Spongilla is a common, widely distributed fresh water sponge shows various shades of green colour because of the symbiotic algae present inside.

***Cliona* (The Boring Sponge)**. The sponge can penetrate the rocks and break them into

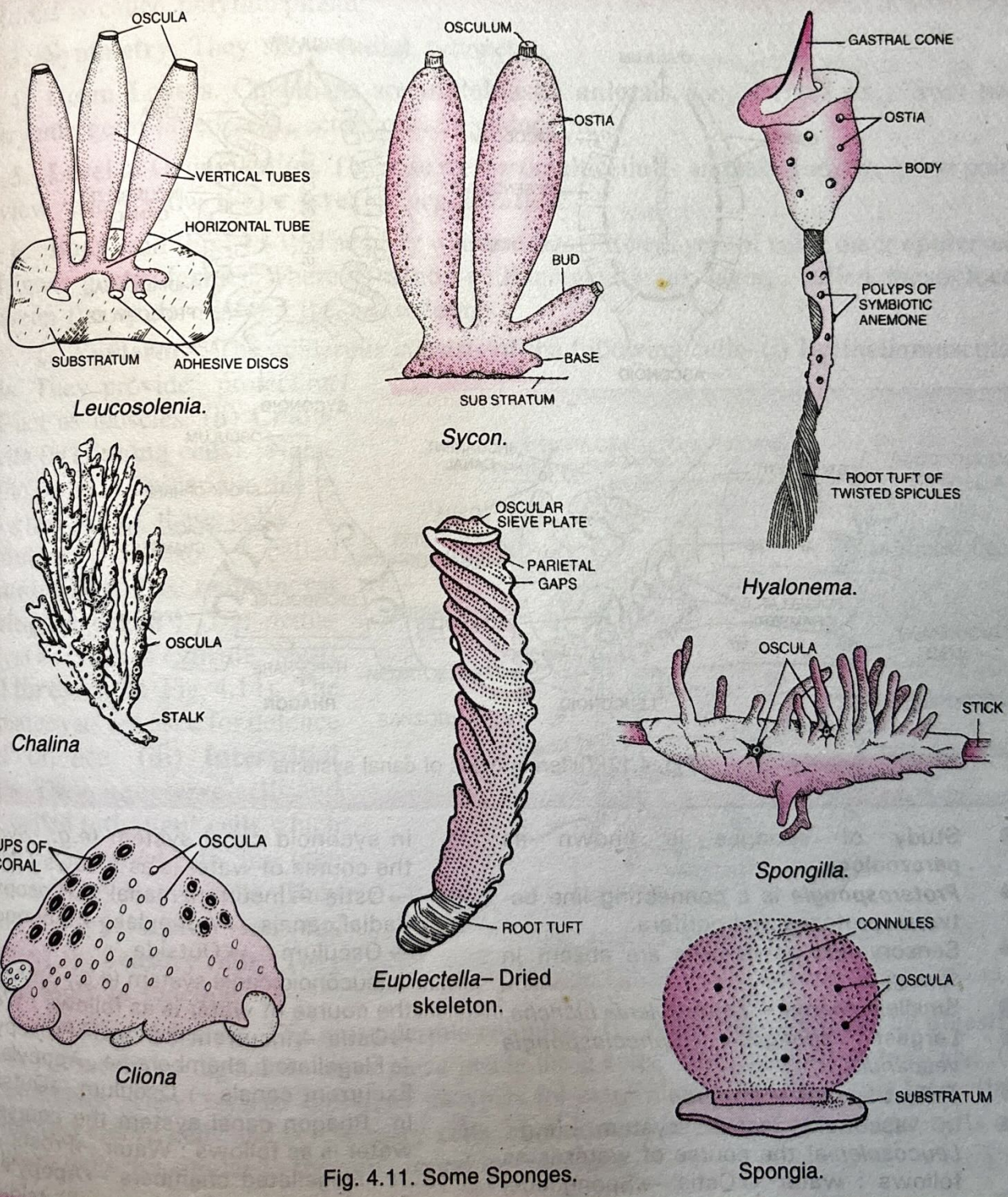


Fig. 4.11. Some Sponges.

pieces. The sponge can also bore through the oyster shell and, therefore, harmful for pearl oyster industry.

Chalina **(The Deadman's Fingers or "The Mermaid's gloves").** The sponge is popularly known as "the deadman's fingers" or "the mermaid's gloves", because it is shaped like a hand with several fingers perforated with oscula.

ADDITIONAL INFORMATION

- *'Olynthus'*- Hypothetical ancestor of sponges.
- In *Leucosolenia* spongocoel is lined by choanocytes (Fig. 4.7).
- In Sycon, incurrent canals are lined by pinacocytes. Radial canals are lined by choanocytes. Spongocoel is also lined by pinacocytes.

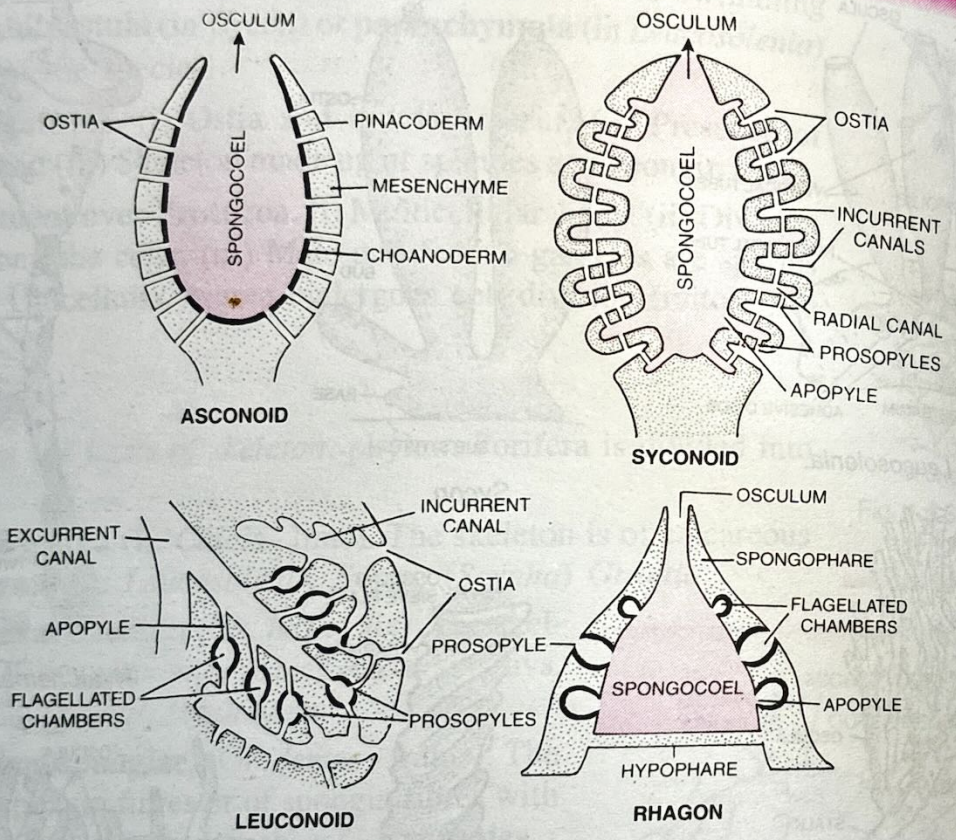


Fig. 4.12. Different types of canal systems

- Study of sponges is known as **parazoology**.
- ***Proterospongia*** is a connecting line between protozoa and porifera.
- Sensory and nerve cells are absent in sponges.
- **Smallest sponge**— *Leucosolenia blancha.*
- **Largest sponge**— *Spheciospongia vesparium*
- **Tallest sponge**— *Poterion*
- In asconoid canal system (e.g., *Leucosolenia*) the course of water is as follows : water → Ostia → Spongocoel → Osculum → Outside.
- In syconoid canal system (*e.g., Sycon*) the course of water is as follows : Water → Ostia → Incurrent canal → Prosopyles Radial canals → Apopyles → Spongocoel → Osculum → Outside
- In leuconoid canal system (*e.g., Spongilla*) the course of water is as follows : Water → Ostia → Incurrent canals → Prosopyles → Flagellated chambers → Apopyles → Excurrent canals → Osculum → Outside.
- In Rhagon canal system the course of water is as follows : Water → Prosopyles → Flagellated chambers → Apopyles → Sponogocoel → Osculum → Outside.

Phylum Cnidaria (= Coelenterata)

(Gk. *knide* – nettle or sting cells)

Peyssonel (1723) and **Trembley** (1744) proved Cnidarians to be animals. **Leuckart** used the term "coelenterata". **Hatschek** (1888) used the term "cnidaria". The phylum Cnidaria includes about 9,000 species.

General Characters

1. **Habitat.** All are aquatic and are mostly marine, except a few like *Hydra,* are fresh water.

2. **Body Form.** Body form varies considerably. Many colonial cnidarians like *Obelia* (Fig. 4.15) are **trimorphic**, having three kinds of **zooids — polyps, blastostyles** and **medusae**. Occurrence of more than one type of individuals in their colonies performing different functions is called **polymorphism**.

3. **Symmetry**. They show **radial** symmetry.

4. **Germ Layers**. Cnidarians are **diploblastic animals,** *i.e.*, derived only from two embryonic germ layers, *viz*., ectoderm and endoderm.

5. **Level of Organization**. They are the first multicellular animals from evolution point of view which show **tissue level of organization**.

6. **Body wall** (Fig. 4.13). The body wall consists of two layers of cells; outer **epidermis** and inner **gastrodermis**. There is a non-cellular gelatinous layer, called **mesogloea**, between the epidermis and the gastrodermis.

1. **Epidermis.** The epidermis consists of the following cells. (i) **Epitheliomuscular cells**. They provide protection and act as muscles. (ii) **Cnidoblasts (= stinging cells)**. Name of the phylum Cnidaria is due to the presence of these cells. A cnidoblast (also called **nematoblast**) has **nematocyst** (**'stinging organ'**). The nematocyst consists of **capsule**, **shaft** and **thread tube** (Fig. 4.14). The nematocysts are used for defence and offence. (iii) **Interstitial cells**. They are reserve cells and are called **totipotent cells** which can be converted into any type of cells. (iv) **Nerve cells**. They form a **primitive nervous system**. (v) **Sensory cells**. They are sensory in function.

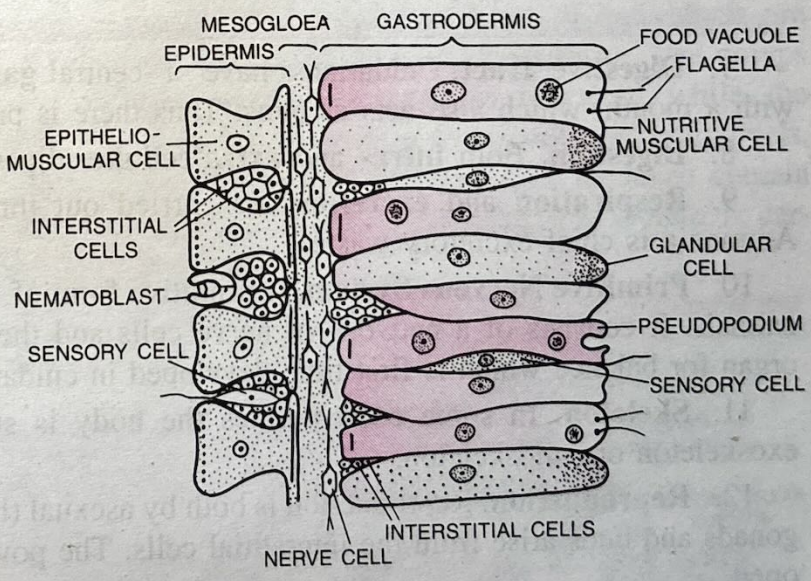


Fig. 4.13. L.S. Body wall of *Hydra*.

2. **Gastrodermis.** The gastrodermis comprises (i) **Nutritive muscular or digestive cells**. Intracellular digestion takes place inside these cells. They also act as muscles; (ii) **Gland cells**. They secrete digestive enzymes for extracellular digestion; (iii) **Interstitial cells**; (iv) **Nerve cells** and (v) **Sensory cells**. Functions of interstitial cells, nerve cells and sensory cells are similar to the cells found in epidermis.

Differences between Nematoblast and Nematocyst	
Nematoblast (cnidoblast)	*Nematocyst*
1. It is a cell present in the epidermis.	1. It is a structure present inside the nematoblast.
2. It is called "stinging cell".	2. It is called "stinging organ".
3. It consists of cell membrane, cytoplasm, nucleus, nematocyst, etc.	3. It consists of capsule, shaft and thread tube. It is used for defence and offence.

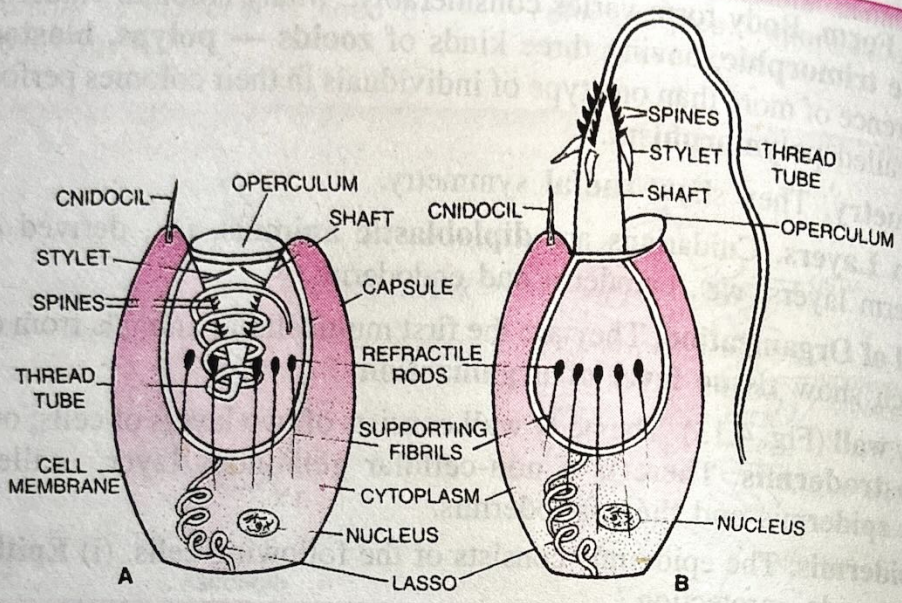


Fig. 4.14. Cnidoblasts. A, Undischarged; B, Discharged.

7. **Digestive Tract**. Cnidarians have a central **gastrovascular cavity** (**coelenteron**) with a mouth, which also acts as anus. Thus there is present **incomplete** digestive tract.

8. **Digestion**. Both **intra-** and **extra-cellular digestion** are present.

9. **Respiration** and **excretion** are carried out through body surface by diffusion. Ammonia is chief excretory waste.

10. **Primitive Nervous System**. A primitive form of 'Nervous system' is found in these animals. It consists of a network of nerve cells and their processes. **Statocyst** is a sense organ for balance which is first time developed in cnidaria.

11. **Skeleton**. In some coelenterates the body is supported by horny or calcareous exoskeleton or endoskeleton.

12. **Reproduction**. Reproduction is both by asexual (budding) and sexual methods. Both gonads and buds arise from the interstitial cells. The power of **regeneration** is also developed.

13. **Development**. The cleavage is **holoblastic**. Direct or indirect development is found. In *Obelia* **planula** larva is present. However in *Aurelia* planula, **scyphistoma** and **ephyra** larvae are found.

14. **Metagenesis.** In *Obelia,* polyps reproduce medusae asexually and medusae form the polyps sexually. Such alternation of asexual and sexual phases in the life cycle of *Obelia* is called **metagenesis**. It should not be confused with alternation of generations as found in plants where one phase is haploid and other is diploid. Here both phases are diploid.

Unique Features. (i) Presence of cnidoblasts for defence and offence. (ii) Network of nerve cells acting as "Primitive Nervous System."

Advancement over Sponges. (i) Tissue level of organisation. (ii) Digestive tract. (iii) Nerve cells and sensory cells.

Classification

Chiefly on the basis of the dominance of medusoid or polypoid phase in the life cycle, the phylum Cnidaria is divided into three classes.

Class 1. Hydrozoa (Gk. *Hydros*– water, *zoon*– animal). Either only polyps are found or polyps and medusae are present. **Examples :** *Hydra, Obelia* (sea-fur) and *Physalia, Porpita, Velella, Millepora* (hydroid coral).

Class 2. Scyphozoa (Gk. *skyphos*– cup). They are represented by medusae. **Examples:** *Aurelia, Rhizostoma*

Class 3. Anthozoa* (Gk. *anthos*– flower). They are represented by the polyp form. Medusa form is absent. **Examples :** *Gorgonia, Adamsia, Alcyonium* (dead man's finger), *Fungia* (mushroom coral), *Pennatula , Gorgonia, Corallium* (red coral), *Astraea, Meandrina, Madrepora* (stag-horn coral), *Tubipora* (organ pipecoral).

Hydra. *Hydra* is a fresh water coelenterate and is carnivorous. *Hydra has great power of regeneration* which was first discovered by **Trembley** (1774). Both bisexual and unisexual *Hydras* are found. A unicellular green alga *Zoochlorella* lives in nutritive muscular cells of *Hydra viridissima* (Green Hydra). The alga utilizes metabolic wastes of host cells like CO_2, water, etc., for photosynthesis. The host *Hydra* is benefitted by utilizing O_2 released in photosynthesis by the alga. Such association by which both organisms are mutually benefitted is called **symbiosis**. *Hydra oligactis* (brown Hydra), *Hydra vulgaris* (colourless *Hydra*) and *Hydra gangetica* (pinkish white Hydra) are some other species.

***Obelia* — The Sea Fur.** Obelia is polymorphic. The three types of individuals are **polyps**, **blastostyles** and **medusae**. The polyps are mainly nutritive in function, while the blastostyles give rise to reproductive individuals, the medusae by budding. The medusae contain gonads for sexual reproduction. *Obelia* is carnivorous.

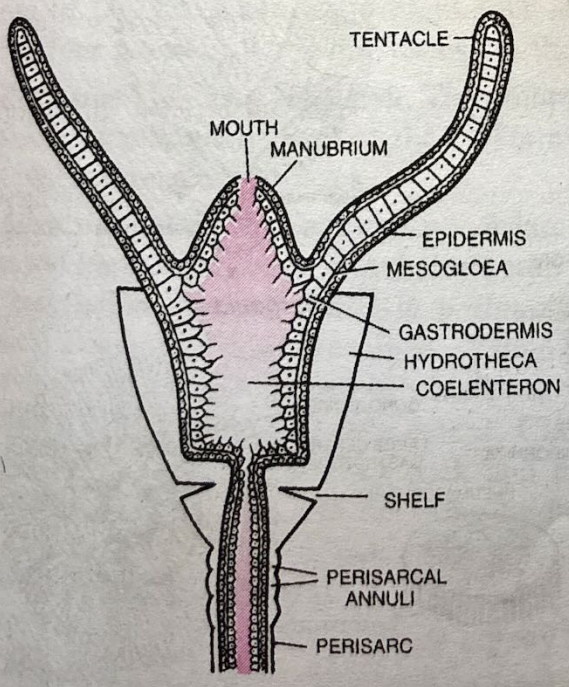


Fig. 4.15. L.S. Polyp.

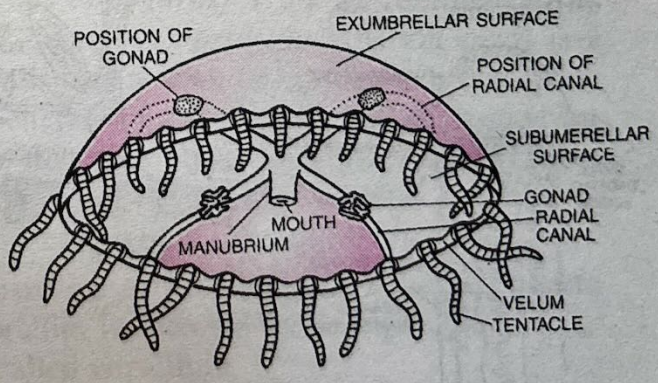
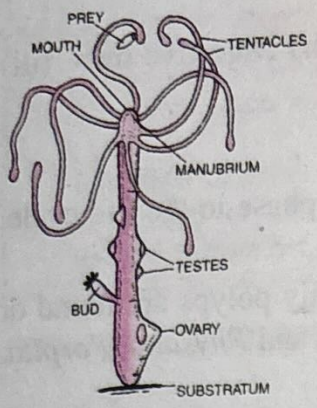
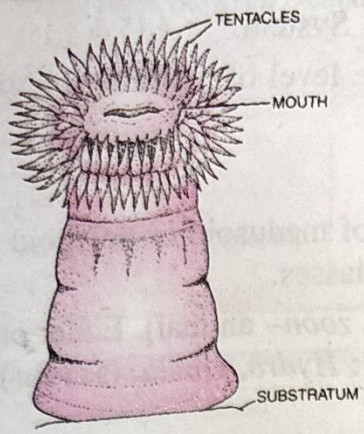


Fig. 4.16. Side view of Medusa.

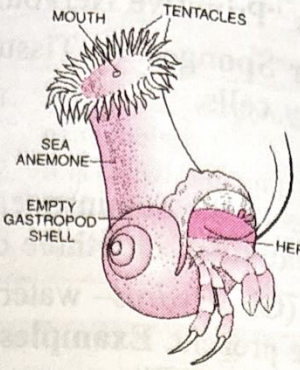
* Also called Actinozoa.



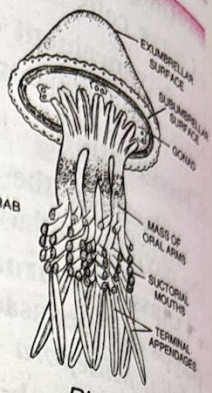
Hydra.



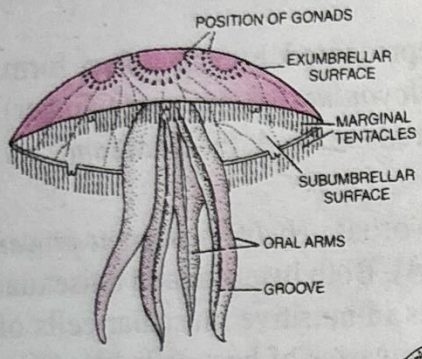
Adamsia.



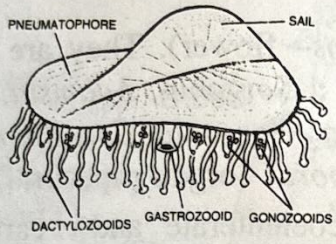
Commensalism between sea anemone and hermit crab.



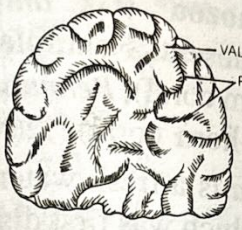
Rhizostoma

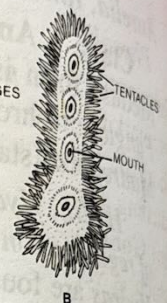


Aurelia.



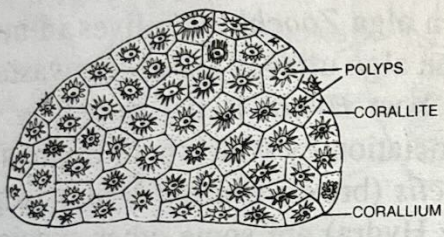
Velella



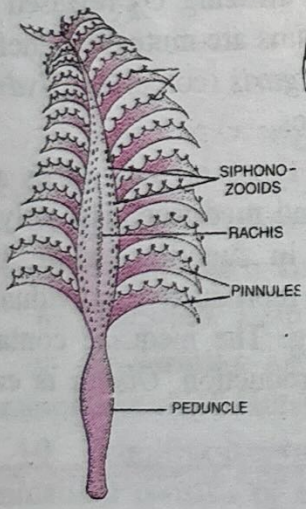


A. Corallium B. Compound polyp

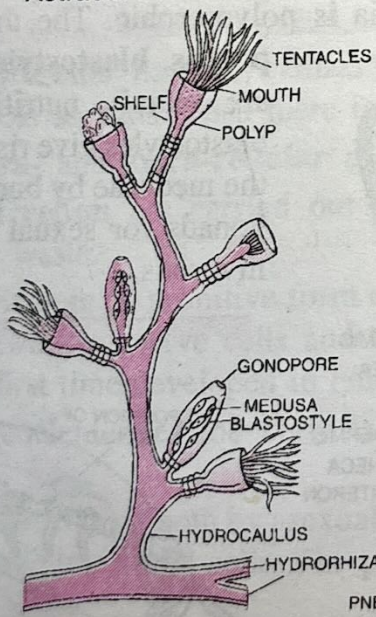
Meandrina sinuosa



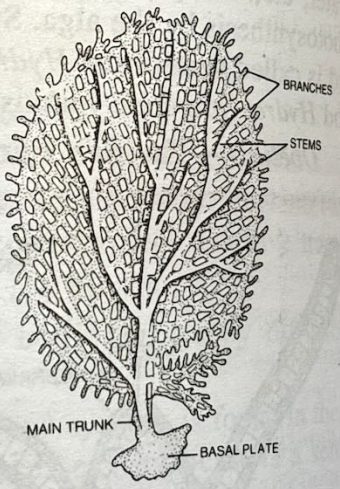
Astraea.



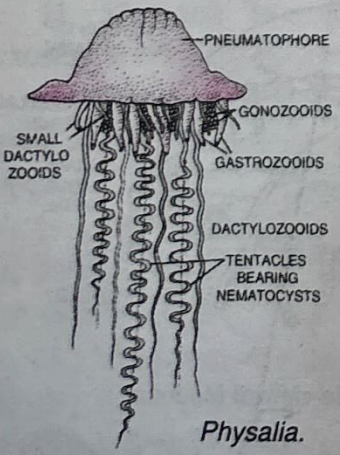
Pennatula.



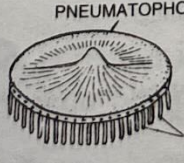
Obelia.



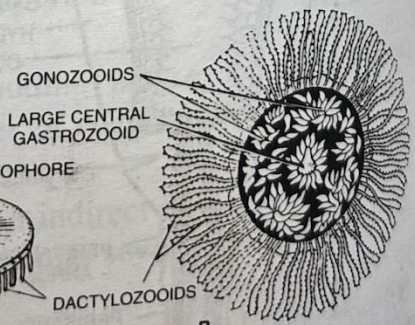
Gorgonia



Physalia.



A. Side View



B. Oral Side

Porpita

Fig. 4.17. Some Cnidarians

Differences between Polyp and Medusa (Fig. 4.15 & 4.16)

Polyp	*Medusa*
1. Polyp is a fixed.	1. Medusa is free swimming.
2. Polyp is cylindrical in shape.	2. Medusa is an umbrella like and formed by blastostyle.
3. Sense organs are absent.	3. There are 8 sense organs called the **statocysts**, each is meant for equilibrium.
4. Polyps are without gonads.	4. Medusa has four gonads.
5. Polyps feed and protect the colony	5. Medusa brings about sexual reproduction and dispersal of species.
6. Polyp belongs to asexual generation.	6. Medusa represents the sexual generation.

***Physalia*— The Portuguese-man-of-war**. A gas gland present inside the pneumatophore secretes a gas which helps the animal to float over the water surface. Physalia exhibits a remarkable example of *polymorphism* and *division of labour.* Just below the pneumatophore are hanging down the three types of zooids and tentacles. (i) **Dactylozooids** serve in catching the food and are also the organs of defence. (ii) **Gastrozooids** are nutritive zooids. (iii) **Gonozooids** are reproductive zooids. The poison of dactylozooids is neurotoxic which is very harmful.

Velella — The "**Sail-by-the wind**". It also shows polymorphism. The pneumatophore is flat and contains air and bears a vertical **sail** on the top. The sail drives the colony along the wind. On the lower side, a single large **gastrozoid** bears mouth. The **gonozooids** bear medusae. The margin of the disc has **dactylozooids** bearing nematocysts.

Porpita — It also shows polymorphism. *Porpita* resembles *Velella* except that it does not have sail and has a circular disc-like pneumatophore.

***Aurelia*— The Jelly fish.** The body of *Aurelia* is somewhat similar to that of the medusa of *Obelia*. There are present four large tapering *oral* arms. *Aurelia* is unisexual bearing four gonads (ovaries or testes) in the subumbrellar side.

***Rhizostoma* — The Jelly fish**. The umbrella shaped body is without marginal tentacles. Numerous mouths are present on the oral arms. The oral arms are bifurcated distally to form eight long terminal appendages.

***Adamsia*— The Sea anemone.** Adamsia is found attached to the empty shell of gastropod (mollusc) occupied by hermit crab (genus *Eupagarus*). It shows **commensalism.** The association between *Adamsia palliata* and *Eupagarus prideauxi* (hermit crab) is a classical example of commensalism. Commensalism is a relationship between two living individuals of different species in which one is benefitted while other is neither harmed nor benefitted except to a negligible extent. **Clarke** describes that sometimes hermit crab obtains sea anemone from a rock and places it on the back of a shell. *Adamsia* is transported from one place to the other by hermit crab which lives inside the shell.

Astraea — **The Star coral.** The polyp possesses a basal cup of calcium carbonate known as **corallite** (skeleton of polyp). The corallite is secreted by the epidermis of the polyp. The exoskeleton of the whole colony is called **corallium.**

***Meandrina sinuosa*— The Brain Coral.** *Meandrina* bears on its surface long winding valleys separated by ridges. The valleys are occupied by **compound polyps** which are formed from ordinary polyps. The surface of the colony is marked by convolutions (fissures) as found in the human brain. That is why *Meandrina sinuosa* is called 'the brain coral.'

***Pennatula*— The Sea pen or Sea feather.** The sea pen looks like a quill (a type of feather). Pennatula is carnivorous and phosphorescent. The colony is **dimorphic** (two types of zooids), (i) **Siphonozooids,** found on the sides of the **rachis** on the dorsal side, cause circulation of water in the canals of the colony. (ii) **Autozooids** are nutritive in function and lie in a single row on each **pinnule**.

***Gorgonia*— The sea fan.** All the branches form a hand-held fan-like network. *Gorgonia* is dimorphic. The zooids are of two types : **autozooids** for feeding and **siphonozooids** for driving a current of water through the colony.

ADDITIONAL INFORMATION

- **Corals.** The corals are hard materials secreted by the tiny living polyps of some colonial cnidarians in the sea. The corals are of two main kinds :

  (1) **Hydrozoan corals.** The polyps of a few colonial hydrozoans form such corals. Example *Millepora.*

  (2) **Anthozoan corals.** The anthozoans form many kinds of corals : (i) **Soft corals.** Example : *Alcyonium* (Dead man's finger). (ii) **Horny corals.** Example : *Gorgonia* (sea fan). (iii) **Blue corals.** Example : *Heliopora.* (iv) **Red corals** : Example : *Tubipora* (organ pipe coral) and *Corallium* (red coral). *Corallium nobile* (Moonga) is used in jewellery hence it is also called precious coral. (v) **True** or **Stony Corals.** Examples : *Fungia* (mushroom coral), *Madrepora* (stag-horn coral), *Astraea* (Star coral) and *Meandrina* (brain coral). They are the major builders of the coral reefs.
- **Coral Reefs.** A coral reef is a ridge or mound in a shallow, tropical sea, has its upper surface near the surface of water, supports a variety of animals and plants and is formed of calcium carbonate produced by some of its inhabitant, chiefly medreporarian corals. *Coral reefs form stable marine ecosystems.* The coral reefs are of three kinds :

  (i) **Fringing reefs.** The coral reefs lie close to the shores of island (A body of land completely surrounded by water). **Hawaiian islands,** in the North pacific ocean under the U.S.A, are an ideal example of permanent fringing reefs. (ii) **Barrier reefs.** They are formed away from the shore. The body of water separates the barrier reefs from land. **Australia's Great Barrier Reef** is an example of such a reef which is over 1920 km long about 80 km wide at certain places and about 145 km from the sea shore. The Great Barrier Reef lies along the north-east coast of Australia. (iii) **Atoll reefs.** An atoll reef is horse shoe shaped reef that surrounds a **lagoon** (water enclosed by an atoll reef) but not an island. It may be complete or broken by a number of channels . The Lakshadweep and Maldive islands in the Indian Ocean are composed of Atoll reef. Thus Lakshadweep (a union territory of India) is coral Island of India.

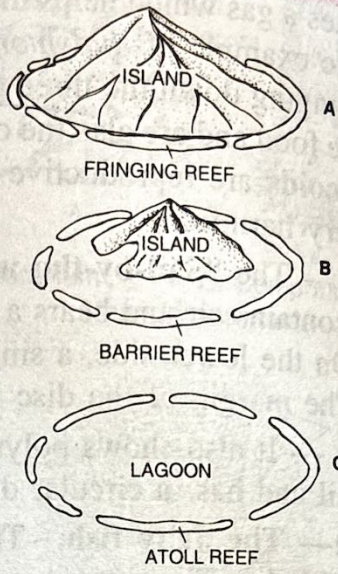


Fig. 4.18. Different types of coral reefs.

- The Pacific Ocean contains more coral formation than any other ocean.
- Totipotent interstitial cells is the characteristic of *Hydra.*
- *Hydra* was discovered by **Leeuwenhoeck** (1703). Its name was given by **Linnaeus** (1758).
- ***"Sea Wasp"*** – a cnidarian is one of the most poisonous animals.
- In India medusae of *Aurelia* are commonly found in coastal waters of Chennai.
- **Types of nematocysts in *Hydra*.**

  1. **Stenoteles** or **penetrants.** These are the **largest.** The thread tube is open at the end. When discharged it releases thread tube by which a poisonous fluid, **hypnotoxin** (chemically protein and phenols) is injected paralysing the prey.

  2. **Holotrichous isorhizas** or **Large glutinants** or **streptoline glutinants.** They

have a narrow butt. The thread is open at the tip. There are small spines on the butt and thread. They stick to the surface of the prey.

3. **Atrichous isorhizas** or **small glutinants or stereoline glutinants.** Butt is absent. Thread is open at the tip and it has no spines. These trichocysts fix the object when *Hydra* walks on its tentacles.

4. **Desmonemes** or **Volvents.** There is no butt. This nematocyst contains a short, thick spineless thread tube which forms a single loop and is closed at the tip. On being discharged, these nematocysts are used to capture the prey.

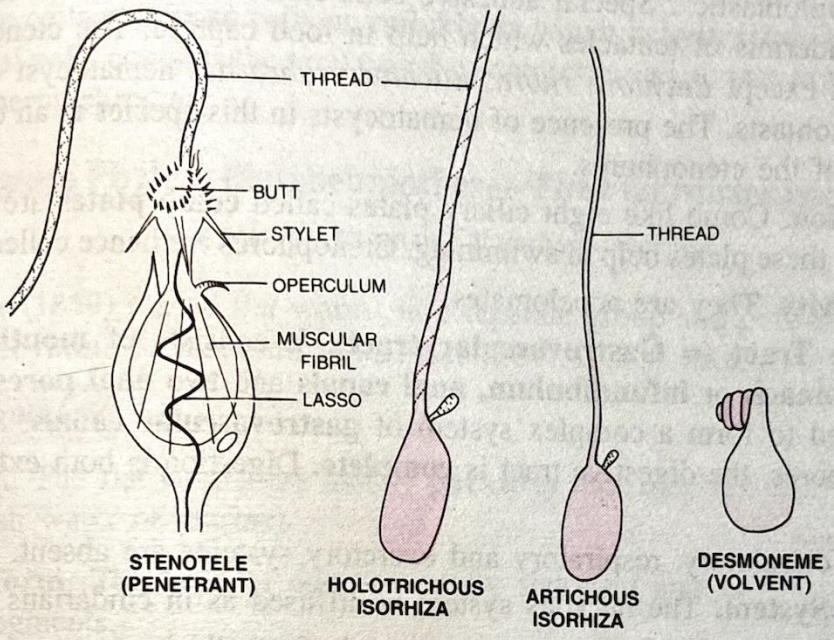


Fig. 4.19. Discharged nematocysts of *Hydra*.

- Thus penetrants and volvents are of particular value in capturing the prey, however, glutinants secrete a sticky substance used in locomotion by fastening the tentacles to solid objects.
- ***Corallium rubrum*** (red coral) has been used widely in jewellery and known as **red moonga**.
- Stimulation for discharge of nematocyst is first mechanical then chemical.
- Myonemes are present in muscular processes of epitheliomuscular and nutritivemuscular cells.
- Mesenteries are the soft internal partitions of a coral polyp or sea animone.

Phylum Ctenophora—The Comb Jellies or Sea Walnuts

(Gk. *ktene*– comb, *phors*– bearing)

The ctenophores as a distinct group were first recognized by **Escscholtz** (1829).

General Characters

There are about 50 species of ctenophores.

1. **Habitat.** All ctenophores are exclusively *marine*.

2. **Habits.** They feed on plankton, swim by cilia. Power of *regeneration is well marked*. **Bioluminescence** (the property of living organism to emit light) is well-marked in ctenophores.

3. **Body Form.** Body form is variable.

4. **Symmetry.** Symmetry is **biradial** (radial + bilateral). The arrangement of comb plates gives the appearance of radial symmetry, the tentacles and branching of gastrovascular canals are of bilateral type.

5. **Germ Layers.** They are **diploblastic** having ectoderm and endoderm.

6. **Level of Organisation.** Tissue level of organization is present.

7. **Appendages.** Tentacles may or may not be present. When present, they are two in number.

8. **Body Wall.** The body wall consists of outer **epidermis**, inner **gastrodermis** and middle **mesogloea** (= **collenchyma**). The mesogloea is different from that of cnidaria as it contains amoebocytes, elastic fibres and muscle cells. From this reason ctenophores may be considered as "triploblastic". Special adhesive cells called **colloblasts** (= **lasso cells**), are present in the epidermis of tentacles which help in food capture. The ctenophores do not have nematocysts except *Euchlora rubra*. *Euchlora rubra* has nematocyst on tentacles. It does not have coloblasts. The presence of nematocysts in this species is an evidence of the cnidarian origin of the ctenophores.

9. **Locomotion.** Comb like eight ciliary plates called **comb plates** are present on the body. The cilia of these plates help in swimming. Ctenophores are hence called **comb Jellies.**

10. **Body Cavity.** They are acoelomates.

11. **Digestive Tract** (= **Gastrovascular tract**). It consists of **mouth, pharynx** or **stomodaeum, stomach** or **infundibulum, anal canals** and two **anal pores**. The stomach is highly branched to form a complex system of **gastrovascular canals**. Since there are mouth and anal pores, the digestive tract is **complete.** Digestion is both **extracellular** and **intracellular**.

12. Skeletal, circulatory, respiratory and excretory systems are absent.

13. **Nervous System.** The nervous system is diffused as in cnidarians.

14. **Sense Organ.** The aboral end (opposite end of mouth) bears a sense organ, called **statocyst** for equilibrium (balance).

15. **Reproduction.** They are monoecious (= hermaphrodite or bisexual). Fertilization is generally external. Asexual reproduction is not present. Paedogenesis is common.

16. **Development.** Egg contains yolk, hence called **lecithal.** Yolk is initially accumulated at the centre (**centrolecithal** condition) but later on when cleavage starts yolk shifts to one side (**telolecithal** condition). Cleavage is complete, holoblastic, unequal, biradial and determinate (a complete embryo is formed if all the blastomeres remain together). Gastrulation occurs by epiboly. The development is indirect with a ciliated spherical **cydippid larva**.

Unique Features. (i) Comb like ciliary plates for swimming. (ii) Special adhesive cells, the colloblasts for capturing the prey. (iii) Mesogloea with amoebocytes and smooth muscle cells. (iv) Two anal pores.

Advancement over Cnidaria. (i) Triploblastic origin of tissue. (ii) Independent muscle cells. (iii) Complete digestive tract. (iv) Determinate Cleavage.

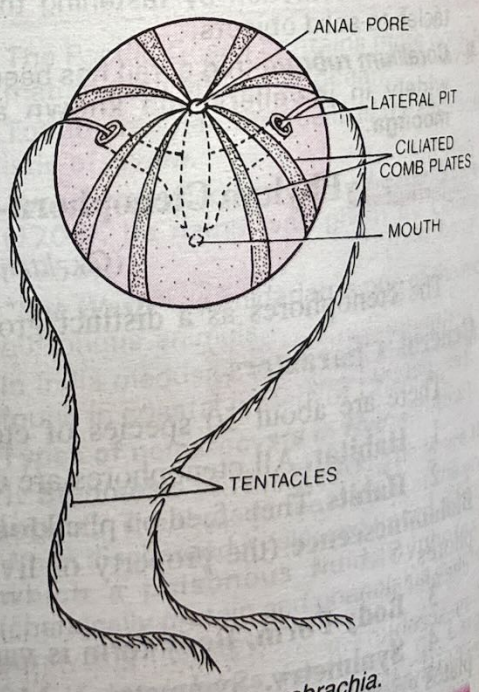


Fig. 4.20. *Pleurobrachia.*

Classification

The phylum ctenophora is divided into two classes: Tentaculata and Nuda.

Class 1 Tentaculata. They have tentacles and small stomodaeum. Examples: *Hormiphora* (The Sea Walnut), *Pleurobrachia* (The Sea gooseberry). *Ctenoplana, Cestum* (The Venus' Girdle).

Class 2 Nuda. Their body is without tentacles. They have spaceous mouth and stomodaeum. Example : *Beroe*.

***Pleurobrachia* — The Sea gooseberry.** *Pleurobrachia* reproduces only sexually. Life history includes a **cydippid larva**. Power of regeneration is well marked. The tentacles bear special adhesive cells, the **lasso cells** or **colloblasts** which help in food capture. The broad end called aboral pole, contains the **anal canals, anal pores** and a sense organ, the **statocyst**. The animal is hermaphrodite.

Phylum Platyhelminthes— The Flat worms

(Gk. *platys*– broad or flat; *helmin*– worm)

Gegenbaur (1859) placed flat worms in a separate group and gave the term **Platyhelminthes**. The phylum Platyhelminthes includes about 13,000 species.

General Characters

1. **Habitat**. The flat worms are mostly **parasites** but some flat worms are free-living (terrestrial, fresh water or marine).

2. **Body form**. The body is dorso-ventrally flattened and is without true segments.

3. **Symmetry**. They show bilateral symmetry.

4. **Germ Layers**. From the evolution point of view, they are the first **triploblastic** animals, *viz.,* consisting of three germ layers : ectoderm, mesoderm and endoderm.

5. **Level of Organization**. The flatworms have **organ-system level of organisation.**

6. **Body wall**. The body covering is soft and may or may not be ciliated. Rod shaped bodies, the **rhabdites** are present in the epidermal cells of the living Platyhelminthes. They are protective and used in food capture.

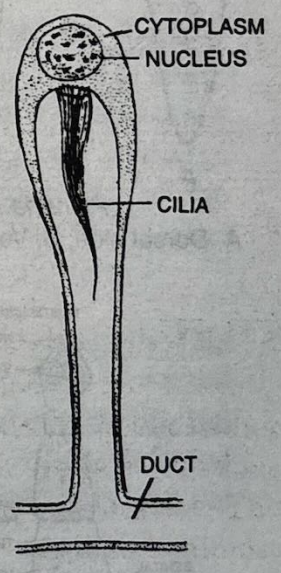


Fig. 4.21. Flame cell.

7. **Body cavity**. The space between the body wall and organs is filled with a peculiar connective tissue, called the **parenchyma**. The parenchyma helps in transporting the food materials. Flat worms are **acoelomates** (without coelom).

8. **Digestive Tract**. The digestive tract, if present, is incomplete (without anus). Digestive tract is absent in tapeworms.

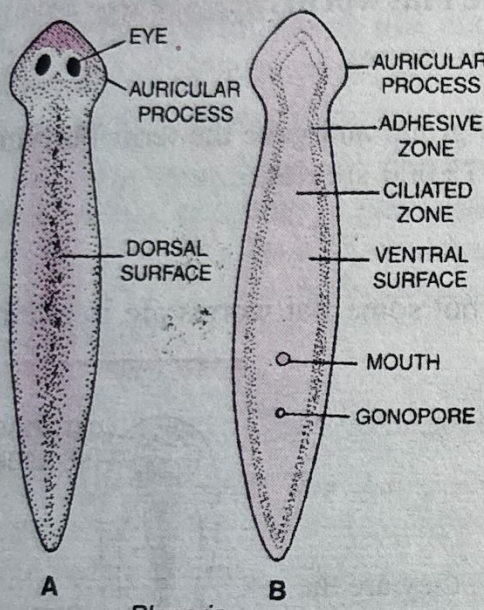
9. **Skeletal, respiratory** and **circulatory systems** are absent. The fluid in the parenchymal network maintains the body shape. It is called **hydroskeleton**. Gaseous exchange in aerobic flat worms occurs by diffusion through body surface.

10. **Excretory system**. It consists of peculiar **flame cells (solenocytes/protonephridia)** which are meant for excretion and osmo-regulation. Ammonia is chief excretory waste.

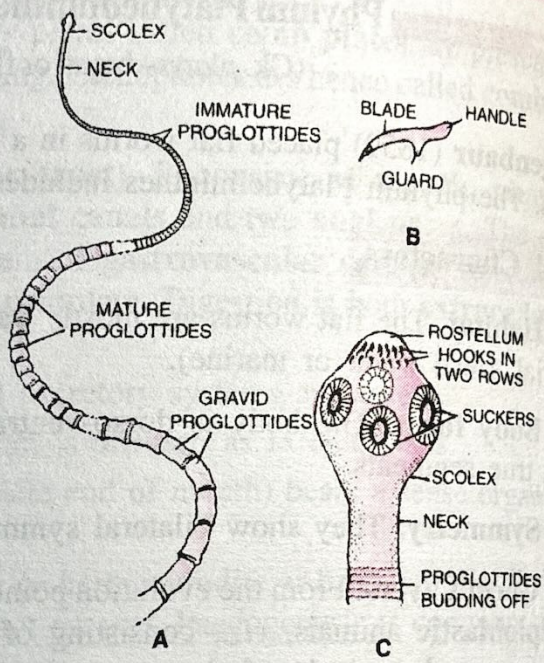
11. **Nervous System**. The nervous system is **ladder-like**. It consists of the brain and two main longitudinal nerve cords connected at intervals by transverse commissures.

12. **Reproductive System**. These animals are generally hermaphrodite, and the reproductive organs are well developed. The fertilization is cross and internal. *In tapeworms self fertilization is found*. Asexual reproduction by **transverse binary fission** occurs in some flat worms.

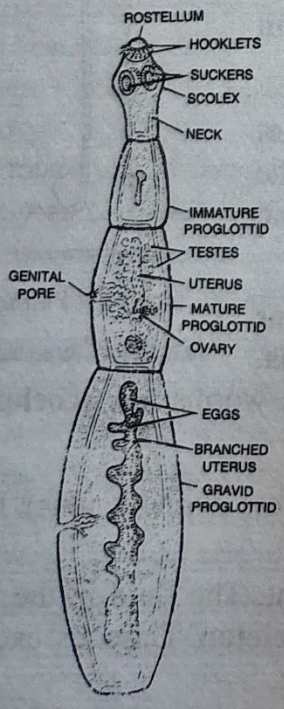
13. **Development**. Life cycle is complicated in most flat worms with one or more larval stages. In liver fluke **miracidium, sporocyst, redia, cercaria** and **metacercaria** larvae are present. In tapeworm **onchosphere, hexacanth** and **cysticercus** larvae are found.



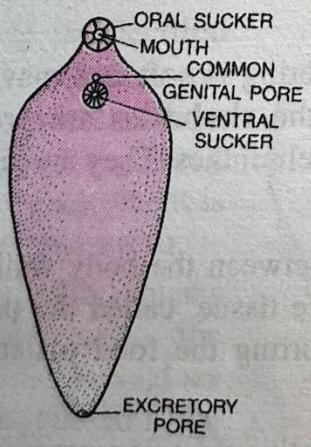
Planaria.
A, Dorsal side; B, Ventral side.



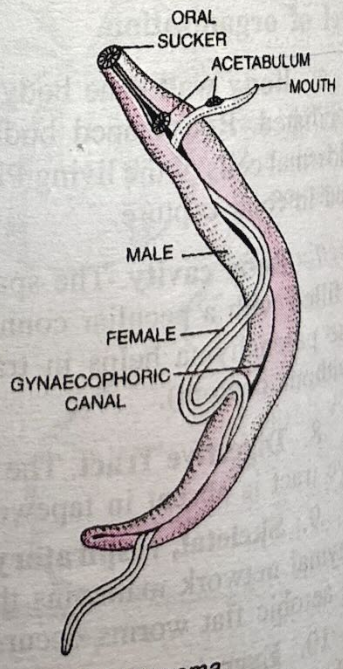
A. Tapeworm; B, Hook; C. Scolex.



Echinococcus granulosus



Fasciola hepatica.



Schistosoma.

Fig. 4.22. Some Flat worms.

14. **Regeneration**. It is well marked in some flat worms like *Planaria*.

Unique Features. (i) Parenchyma. (ii) Flame cells. (iii) Ladder-like nervous system. (iv) Self-fertilization occurs in some flat worms (*e.g., Tapeworms*).

Advancement over Ctenophores. (i) Triploblastic. (ii) Organ-system level of organisation. (iii) Gonoducts and copulatory organs.

Classification. Chiefly on the basis of mode of life, phylum platyhelminthes is divided into three classes.

Class 1. Turbellaria (L. *turbella*– stirring). These are mostly free-living flatworms. **Examples.** *Dugesia* (= *Planaria*).

Class 2. Trematoda (Gk. *trema*– *hole* + *eidos* = form). These are ecto or endoparasitic worms (flukes) **Examples.** *Fasciola, Schistostoma*, *Polystomum* (endoparasite of the urinary bladder of frog and turtles).

Class 3. Cestoda. (Gk. *kestos*– *girdle* + *eidos* = form). These worms are endoparasites of vertebrates. The body is generally divided into a few to many **proglottides** (not true segments). **Examples.** *Taenia, Echinococcus*.

***Dugesia* (Planaria).** It is found in slow moving streams or fresh water ponds. It bears cilia on its body. It has a great power of regeneration. The heads bear two lateral lobes, the **auricular processes**, and a pair of **eyes.**

***Schistosoma*.** It is commonly called the **"blood fluke"** as it lives in the hepatic portal system and mesenteric blood vessels of human beings. Its intermediate host is snail. The male carries the female permanently in the **gynaecophoric canal**. *Schistosoma* shows well marked **sexual dimorphism**. After fertilization the female leaves the male and lays eggs in the smaller blood vessels. *Schistosoma* causes **schistosomiasis.** The symptoms of the disease are diarrhoea, anaemia, enlargement of liver and spleen, pain and fever. The disease can be prevented by not taking contaminated water. OR Bilharziasis

***Fasciola*— The Liver fluke**. Adult *Fasciola hepatica* is found in the liver and bile duct of sheep, goat which are its **primary hosts**. The **secondary** or **intermediate host** is a pond snail (a mollusc) of genus *Limnaea* and genus *Planorbis*. The fluke is hermaphrodite but there is cross fertilization. It causes a disease known as **liver rot (fascioliasis)**. The infected animal feels great muscular weakness resulting in muscular pain. The liver enlarges and the bile ducts are blocked. The disease may prove fatal to the animal.

***Taenia solium*— The Pork Tapeworm**. It is found in all those countries, where pork is taken as food. The adults of *T. solium* are parasites in the small intestine of human beings (**primary host**) and its larva is found in the muscles of the pig mostly (**secondary host**). The tapeworm does not have alimentary canal. The digested food of the host is diffused directly through the general body surface. *T. solium* is hermaphrodite. There is self fertilization. The body is divisible into three parts : **scolex, neck** and **strobila**. At the top of the scolex lies a cone like **rostellum**. The rostellum bears at its base about 22–32 small curved chitinous **hooks** placed in two circlets. Hooks of the posterior circlet are somewhat smaller than those of the anterior one. On the middle part of the scolex there are present 4 cup-like muscular **suckers**. The suckers and hooks are the organs of attachment. The strobila consists of immature, mature and gravid proglottides. Proglottides show pseudometamerism (external segmentation only). *Both mouth and anus are absent.*

Tapeworm causes **taeniasis**. This disease can be characterized by such symptoms as abdominal pain, restlessness, anaemia, false appetite and indigestion.

Cysticercosis caused by **cysticercus** (bladder worm) is more dangerous than taeniasis. Cysticercus is a larva of tapeworm which develops from another larva, the **onchosphere**. Sometimes, the onchospheres reach human stomach directly with contaminated food and water or by antiperistalsis of intestine. These onchospheres develop into bladder worms in man and thus, man become accidently intermediate host of the tapeworm. The bladder worms may reach the eyes where they may undergo encystment and cause blindness or in the brain they can cause epilepsy.

***Taenia saginata* (Beef tapeworm)**. It lives in the human intestine of beef eating persons. Its intermediate hosts are cattle and buffaloes. It is longer than *Taenia solium*. Its body is divisible into scolex, neck and strobila. The scolex bears four adhesive suckers but it does not have rostellum and hooks. Its infection occurs by taking under cooked beef.

Differences between Immature, Mature and Gravid Proglottides of a Tapeworm

Immature Proglottides	*Mature Proglottides*	*Gravid Proglottides*
1. Reproductive organs are not developed.	Both male and female reproductive organs are well developed.	Reproductive organs are obliterated.
2. Uterus is not present.	Uterus is small and unbranched.	Uterus is branched and filled with capsules (containing fertilized eggs).
3. There is no shedding of proglottides.	There is no shedding of proglottides.	There is shedding of proglottides called **apolysis**.

***Echinococcus granulosus* – The dog tapeworm** or **hydatid worm**. It lives as an endoparasite in the intestine of dogs, cats and foxes, etc. Man sometimes serves as an incidental host. The dog tapeworm consists of a **scolex, neck** and **strobila**. **Storbila** consists of 3 or 4 proglottides : one immature, one or two mature and one very large gravid. Man acquires infection by playing with pet dogs. The hydatid worm causes **hydatid disease** in man. Presence of cysts of this worm in the brain and kidney may prove fatal.

Peculiar Features that you find in Parasitic Platyhelminthes

(1) The thick tegument (body covering) resistant to the host's digestive enzymes and anti-toxins. (2) Adhesive organs like suckers in flukes and the hooks and suckers in tapeworms for a firm grip on or in the host's body. (3) Loss of locomotory organs. (4) Digestive organs are absent in tapeworms because digested and semidigested food of the host is directly absorbed through the body surface. (5) There is total absence of sense organs in parasitic flatworms. (6) Reproductive system is the best developed in parasitic flatworms. They are mostly hermaphrodite. In some parasitic flatworms like tapeworms self fertilization takes place. Thus large number of eggs are produced. (7) Parasitic flatworms, such as liver fluke and tapeworms perform anaerobic respiration. (8) They possess a considerable osmotic adaptabiliy, as they can successfully live in different media. (9) A fertilized egg, along with one or more yolk cells is covered by a resistant shell, which is protective in function.

ADDITIONAL INFORMATION

- **Brief Life Cycle of Liver Fluke.**

Adult fluke in the liver of sheep or goat
↓
Capsules containing zygotes
↓
Zygote gives rise to **Miracidium** (1st Larva)
↓
Miracidium enters the snail
↓
Miracidium changes to **Sporocyst** (2nd Larva)
↓
Sporocyst produces **Rediae** (3rd larvae) by parthenogenesis (paedogenesis)
↓
Redia produces **Cercariae** (4th larvae) by parthenogenesis (paedogenesis)
↓
Cercariae come out of the snail
↓
Cercariae change to **Metacercariae** (5th Larvae)
↓
Metacercariae get attached to water weeds
↓
Weeds and Metacercariae are eaten by sheep or goat
↓
Metacercaria changes to young fluke
↓
Adult fluke in the liver of sheep or goat

- **Brief Life Cycle of Tapeworm** (*Taenia solium*).

Adult tapeworm in human gut
↓
Fertilized ova (zygotes) in the mature proglottides
↓
Capsules containing zygotes in gravid proglottides
↓
Onchospheres (larvae) in the gravid proglottides
↓
Onchospheres in human faeces (outside the body)
↓
Faeces containing onchospheres is eaten by pig
↓
Each onchosphere contains a **hexacanth**
↓
Hexacanths penetrate the gut of the pig
↓
Hexacanths in the blood of pig
↓
Hexacanths in the muscles of pig
↓
Hexacanths develop into **cysticerci** (larvae)
↓
Cysticerci in the human gut
↓
Each cysticercus develops into young tapeworm in the human gut
↓
Adult tapeworm in human gut

- Tapeworms are said to be "Wallowers" because they absorb nourishment through their body surface.
- *Opisthorchis*– Chinese or oriental liver fluke.
- *Fasciola gigantica* – Cattle liver fluke.
- *Diphyllobothrium latum* – Fish tapeworm.

Phylum Aschelminthes or Nemathelminthes — The Round worms

(Gk. *nema*– thread, *helmin*– worm)

Gegenbaur (1859) proposed the term '**Nemathelminthes**'. The phylum Nemathelminthes includes about 15,000 species.

General Characters

1. **Habitat.** Many roundworms live as parasites in plants and animals. They cause serious agricultural, veterinary and human health problems. Round worms are also free living and occur in fresh water, sea water and soil.

2. **Body Form.** They are called round worms because they appear circular in cross section. They are unsegmented.

3. **Body wall.** It consists of firm, non living resistant **cuticle**, **syncytial epidermis** (a continuous layer of cytoplasm with scattered nuclei) and **muscle layer.**

4. **Body cavity.** The body cavity is called **pseudocoel** or **pseudo-coelom** as it develops from the blastocoel of the embryo. Pseudocoel is filled with **pseudocoelomic fluid.**

5. **Digestive Tract.** Alimentary canal is **complete** with **muscular pharynx.**

6. **Skeletal, respiratory** and **circulatory systems** are absent. **Pseudocoelomic fluid** present in the pseudocoelom maintains body shape and forms **hydroskeleton.** Gaseous exchange in aerobic respiration occurs by diffusion through the body surface. The pseudocoelomic fluid transports materials.

7. **Excretory System.** The excretory system consists of gland cells, or of canals or of both. In *Ascaris*, 'H' shaped excretory system of canals and complicated "giant cell" called "**renette cell**" is present. Ammonia is main excretory matter. However, *Ascaris* also excretes urea.

8. **Nervous System.** It consists of a **circumpharyngeal ring** that gives rise to nerves forwards as well backwards.

9. **Sense Organs.** (i) **Papillae** (raised structures) occur on the lips, on the sides of anterior end in both male and female and in front and behind the cloacal apperture. All papillae are tactile in function. (ii) **Amphids** (pits) are present on the lips and are chemoreceptors. (iii) **Phasmids** are unicellular glands located upon lateral sides of the posterior end and are glandulosensory in nature.

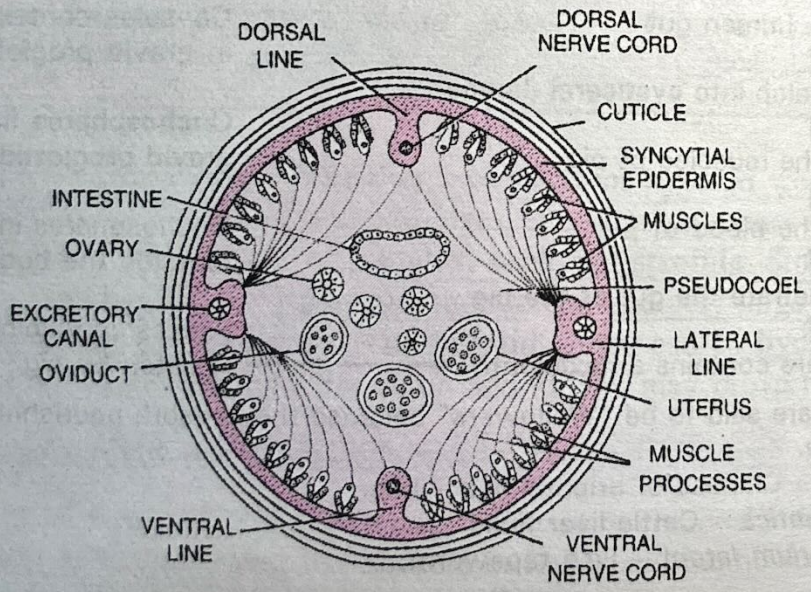
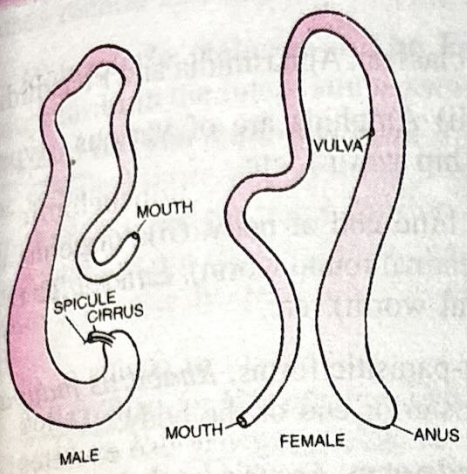


Fig. 4.23. T.S. Female *Ascaris.*

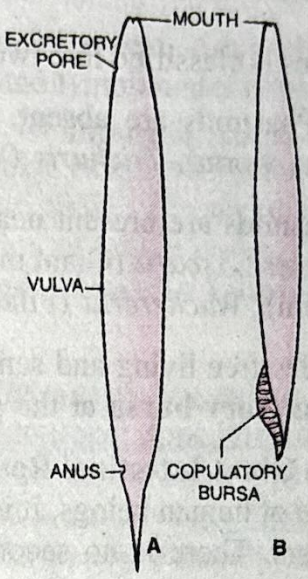
10. **Sexes.** Sexes are separate (**dioecious**). Generally they show **sexual dimorphism,** often females are longer than males. Fertilization is internal. There is no asexual reproduction.

11. **Development.** Development may be direct or indirect. During indirect development a larva is present. **Filariform** larva is present in *Ancylostoma* (hook worm), **microfilaria** larva is found in *Wuchereria* (filarial worm) and **Rhabditiform** larva is present in *Ascaris* and *Enterobius* (pin worm).

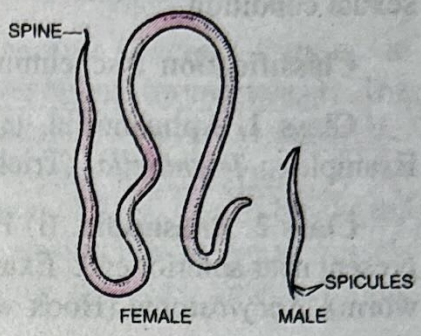
Unique Features. (i) Syncytial epidermis. (ii) Muscle layer of body wall consists of longitudinal fibres only. (iii) Pseudocoel.



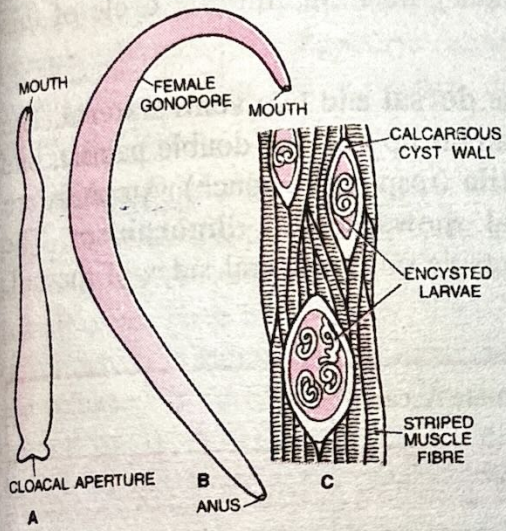
Trichuris.

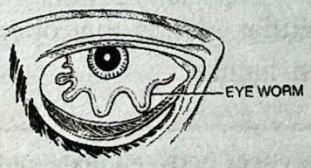


Rhabditis.
A, Adult female;
B. Adult male.



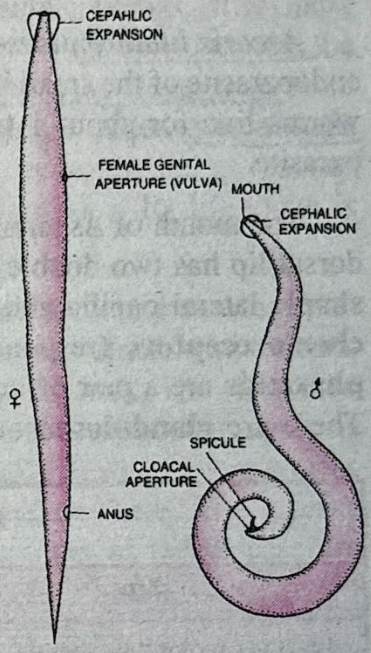
Dracunculus.



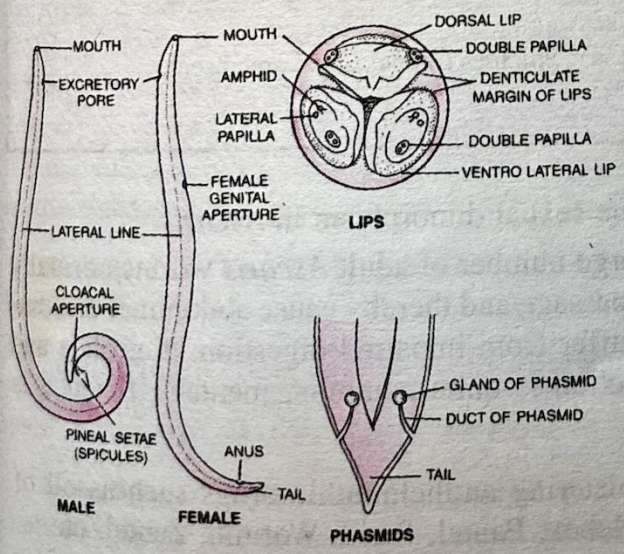


Loa loa

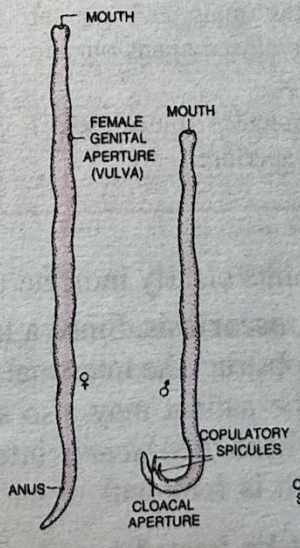
Trichinella Spiralis, A, Male B, Female
C, Encysted larvae in striped muscle of pig.



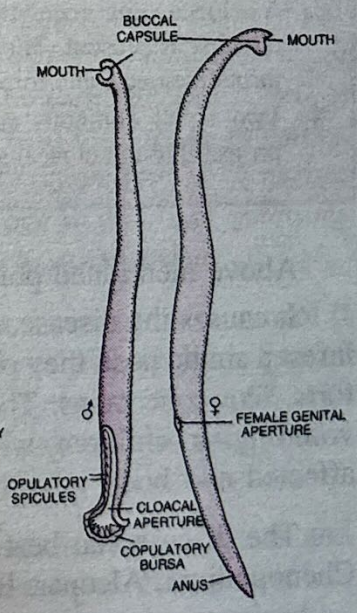
Enterobius.



Ascaris.



Wuchereria



Ancylostoma

Fig 4.24. Some Round worms.

Advancement over Flatworms. (i) Pseudocoel. (ii) Complete digestive tract. (iii) Unisexual condition.

Classification. Aschelminthes is classified into two classes : Aphasmidia and Phasmidia.

Class 1. Aphasmidia. (i) Phasmids are absent. (ii) Amphids are of various types. Examples : *Trichinella,* (Trichina worm), *Trichuris* (Whip worm), etc.

Class 2. Phasmidia. (i) Phasmids are present near hind end of body. (ii) Amphids are present near anterior end. Examples : *Ascaris* (Giant intestinal round worm), *Enterobius* (Pin worm), *Ancylostoma* (Hook worm), *Wuchereria* (Filarial worm), etc.

Rhabditis. This genus includes free living and semi-parasitic forms. *Rhabditis maupasi* lives in soil. The male has **copulatory bursa** at the posterior end of the body.

***Ascaris lumbricoides*— The Giant Intestinal Roundworm.** *Ascaris lumbricoides* is an endoparasite of the small intestine of human beings. It is more common in children. The adult worms live for about 1 to 2 years. There is no secondary host in the life cycle of this parasite.

The mouth of *Ascaris* is bounded by three lips: one **dorsal** and two **ventrolateral**. The dorsal lip has two double papillae, while each ventrolateral lip has one double papilla, one simple lateral papilla and a **amphid**. Papillae are **tactile** (respond to touch). Amphids are **chemoreceptors** (respond to chemicals). The animal shows **sexual dimorphism**. The **phasmids** are a pair of unicellular glands that open outside on the lateral sides of the tail. These are **glandulosensory** in nature.

Differences between male and female Ascaris

Male	*Female*
1. It is smaller than female.	1. It is larger than male.
2. Posterior end is curved.	2. Posterior end is straight.
3. A cloaca, for receiving anus and genital opening is present. The cloaca opens outside through cloacal aperture.	3. There are separate anus and genital aperture. No cloaca is present.
4. Two equal chitinous spicules (pineal setae) project through cloacal aperture.	4. Spicules (pineal setae) are absent.

Above mentioned points clearly indicate the sexual dimorphism in *Ascaris*.

It causes the disease, **ascariasis**. Since a large number of adult *Ascaris* worms normally infest a single host, they obstruct the intestinal passage and thereby cause abdominal discomforts, like colic pains. The patient may also suffer from impaired digestion, diarrohea and vomiting. In children, where the *Ascaris* infection is quite common, mental efficiency is affected and body growth is retarded.

The disease can best be treated by administering antihelminthic drugs such as oil of Chenopodium, Alcopar, Bendex, Dewormis, Mebex, Pantel, Parid, Wormin, Zentel, etc.

***Ancylostoma duodenale*— The Hook worm.** It is found as an endoparasite in the small intestine of human beings. No intermediate host is required. Its larvae enter the human body from moist soil by boring through the skin of the feet. There is distinct sexual dimor-

phism. It causes acute anaemia due to extensive injury to the host intestinal wall. It also causes mental and physical deficiency. The disease is called **ancylostomiasis.**

***Wuchereria* (Filaria)— The Filarial worm.** Adult *Wuchereria bancrofti* lives as an endoparasite in the lymphatic vessels and lymph nodes of human beings (primary host). The mosquito (certain species of *Culex*) is the intermediate host. Thus its life cycle is **digenetic**. The female *Filaria* gives rise to juveniles called **microfilariae**. So it is **viviparous**. In the lymph glands, the juveniles develop into adults. The accumulation of these worms blocks the lymphatic system resulting inflammation of lymph nodes. The obstruction of lymph vessels causes a serious disease known as **elephantiasis (= Filariasis)** in the legs, arms, scrotum, etc.

***Enterobius* (= Oxyuris)— The Pin worm**. *Enterobius vermicularis* (vern.– "Chunna") is found in the caecum, colon or vermiform appendix of the human beings. It is more common in children. There is also distinct sexual dimorphism. Eggs are deposited around the anus. The patient scratches the affected area. The eggs easily get under the finger nails from where they may get into the mouth. The disease caused by *Enterobius* is called **enterobiasis (oxyuriasis)** in which the worm causes intense itching of the anus, inflammation of mucous membrane of colon and appendix, nausea, abdominal pain and diarrhoea. Its life cycle is **monogenetic**.

Trichinella*— The Trichina worm.** Adult *Trichinella spiralis* is found in the small intestine of human beings and some other mammals like pigs, domestic animals and rodents, however, its encysted larvae are present in the striated muscles of the host. The fertilized female gives birth to juveniles. Thus it is ***viviparous. If partly cooked meat containing cysts of the worm is eaten by the man, the cysts are taken into the small intestine where worms are released from the cysts. The worms become mature and copulate there. The disease caused by *Trichinella spiralis* is called **trichinellosis**. The symptoms of the disease are diarrhoea, nausea (feeling of vomiting), abdominal pain, muscular pain, etc.

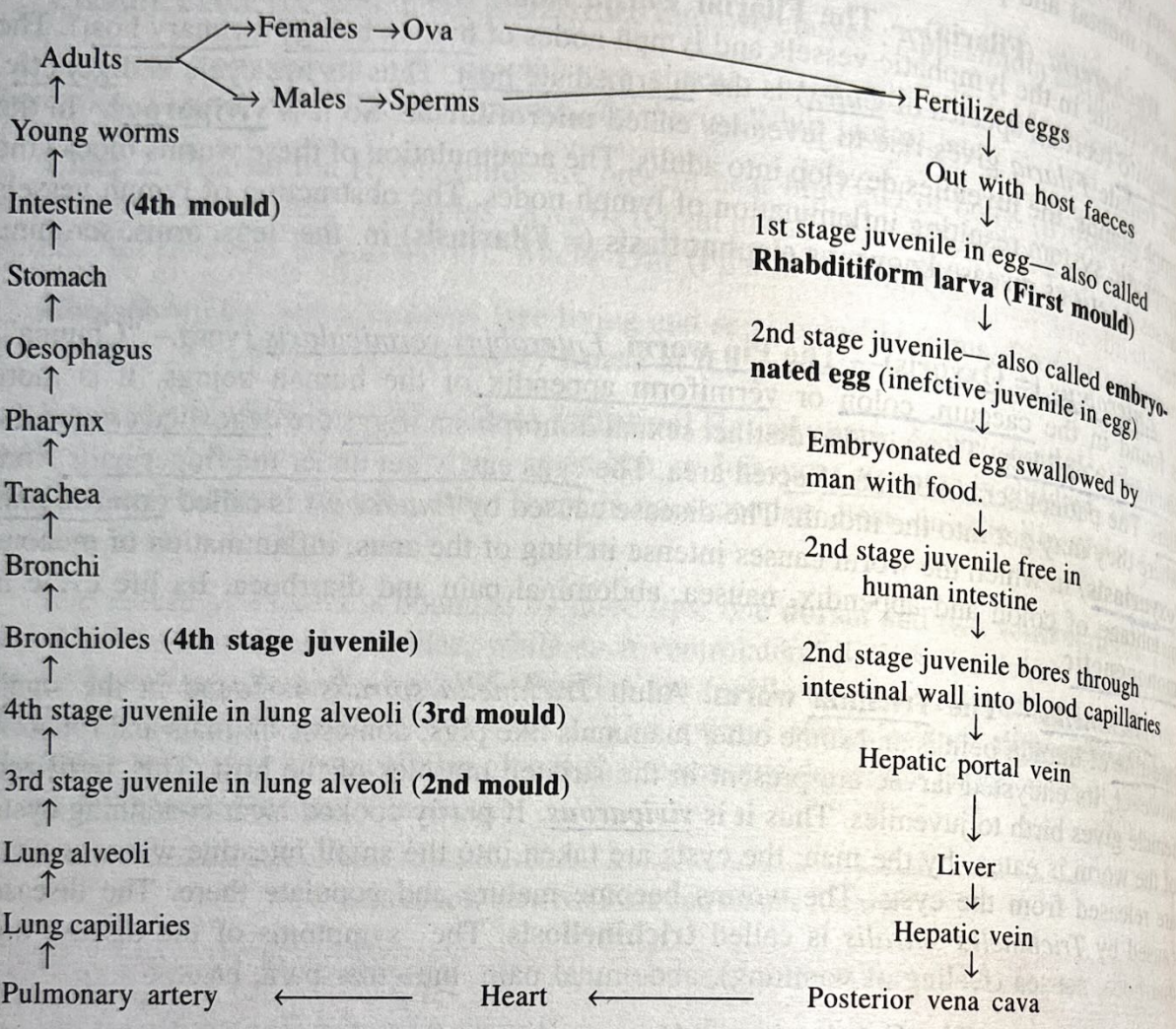
***Dracunculus*— The Guinea worm**. *Dracunculus medinensis* occurs in the subcutaneous tissue of man. The parasite produces toxic secretions which cause a blister on the skin of the host. When the host comes in contact with cold water, the female worm found below the skin, releases larvae in the water. The larvae penetrate the body of *Cyclops,* a fresh water crustacean which is the intermediate host of the guinea worm. When the infected *Cyclops* is taken in by man with water, the larvae escape from the *Cyclops* into the human intestine. The larvae bore their way to the subcutaneous tissue where they become adults. The guinea worm causes itching, diarrhoea, nausea, vomiting and eosinophilia due to its toxic secretions in the human body. The disease caused by this worm is called **dracunculiasis.**

***Trichuris*— The Whip worm.** *Trichuris trichiura* is whip shaped hence it is so named.It lives in the caecum, appendix and colon of man, especially children. The eggs are passed out with the faeces of the host. New host gets infection by ingesting the embryonated eggs with contaminated food or water. Its infection causes gastrointestinal troubles (abdominal pain, diarrhoea). It also causes anaemia as it sucks blood of the host.

Loa-loa— The Eyeworm. *Loa loa* lives in the subdermal connective tissue of man and baboons (large monkeys of Africa and Southern Asia with a dog-like face). Man gets infection by bites of infected deerfly ***chrysops***. Loa loa causes **loiasis**, a disease characterised by subcutaneous swelling (called **calabar swelling**) mostly around the eyes. This parasite may produce conjunctivitis in the eye.

ADDITIONAL INFORMATION

- **Brief Life Cycle of Ascaris.**



- **Dual Excretory Waste.** *Ascaris* is both **ammonotelic** and **ureotelic**.
- **Monorchic.** Presence of single testis, *e.g.*, Male *Ascaris*.
- **Didelphic.** Presence of two uteri, *e.g.*, Female *Ascaris*.
- *Ancylostoma duodenale* (Hookworm) was discovered in 1838 in an autopsy of an Italian peasant woman by **Dubini**.
- (i) **Rhabdites.** These are rod shaped hyaline bodies which occur in the epidermal cells of turbellarian epidermis. (ii) ***Rhabditis***. It is a free living round worm which lives in soil. (iii) **Rhabditoid** or **Rhabditiform**. It is the larva of *Ascaris*.

Phylum Annelida— the Segmented Animals

(Gk. *annulus*– ring; *lidos*– form)

Lamarck (1801) established phylum **Annelida**. He gave the term Annelida. The phylum Annelida includes over 9,000 species.

General Characters

1. **Habitat.** Annelids occur in fresh water, sea water or moist soil. Some are free living, some are burrowing and a few are parasitic.

2. **Metameric Segmentation.** The annelids are characterised by metameric segmentation, *viz.*, the body is divided externally by ring like grooves the **annuli** (Latin, *annulus*: little ring) and internally by transverse **septa**. The segments are called **metameres**. The first

segment is called **peristomium**. An outgrowth, known as **prostomium**, arises from the peristomium.

3. **Setae and Parapodia**. Except leeches, unjointed chitinous **setae** are often present. Some annelids such as *Nereis* have unjointed, locomotory structures, the **parapodia** (*para–* parallel, *podia–* feet).

4. **Body wall**. The body wall consists of thin, and moist noncellular **cuticle**, single layered **epidermis** and **circular** and **longitudinal muscles**. The muscles are smooth which are highly contractile and help in locomotion.

5. **Coelom (Body cavity)**. A true coelom is present. From evolution point of view, annelids are, perhaps, the first animals to have a true **schizocoelic coelom**. In most annelids coelom is divided by septa into compartments. The coelom is filled with **coelomic fluid** which contains cells.

6. **Hydroskeleton**. The coelomic fluid serves as a hydroskeleton.

7. **Digestive Tract**. It is complete.

8. **Respiratory Organs**. Exchange of gases usually occurs through the skin (**cutaneous respiration**). In some annelids gaseous exchange also occurs through gills (**branchial respiration**).

9. **Blood Vascular System**. It is usually closed type. Blood is red due to the presence of respiratory pigment **haemoglobin** or **erythrocruorin**, found dissolved in the blood plasma. Free **amoeboid blood corpuscles** are present, but there are no red blood corpuscles. In leech, there is no true blood vascular system, the coelomic space and fluid have been modified to form the circulatory system. It is called **haemocoelomic system** and red coelomic fluid is called **haemocoelomic fluid**.

10. **Excretory System**. It consists of coiled tubular structures, called **nephridia** which help in osmoregulation and excretion. Ammonia is chief excretory waste.

11. **Nervous system**. The nervous system consists of a **nerve ring** and a solid, double, mid ventral **nerve cord** with **ganglia**. A ganglion is an aggregation of nerve cells.

12. **Receptors. Tactile receptors** (sensitive to touch), **gustatoreceptors** (receptors of taste) and **photoreceptors** (sensitive to light) are usually found. Some forms have **statocysts** (balancing organs).

13. **Sexes.** Both unisexual (*e.g., Nereis*) and bisexual (*e.g.,* Earthworm, Leech) forms are found.

14. **Development**. It is mostly direct. If there is indirect development (*e.g., Nereis*), it includes a **trochophore** larva.

Unique Features. (i) Metameric segmentation. (ii) Haemoglobin in the plasma. (iii) Nephridia for excretion and osmoregulation. (iv) Setae.

Advancement over Roundworms. (i) Metameric segmentation. (ii) Circular and longitudinal muscles are present in both body wall and the wall of the alimentary canal. (iii) True coelom. (iv) Blood vascular system contains red blood.

Classification. On the basis of number and presence or absence of setae phylum Annelida is divided into five classes.

Class 1. Polychaeta (Gk. *polys–* many + *chaete* = hair). They have well developed **parapodia** with numerous **setae**. The development is indirect, undergoing metamorphosis with a free swimming **trochophore** larva. **Examples :** *Nereis*, *Aphrodite* (Sea mouse) *Polynoe* (Scaleworm), *Chaetopterus* (Paddle worm), *Sabella* (Peacock worm), *Arenicola* (Lug

worm), *Amphitrite, Terebella* and *Serpula* (Fan worm). Both *Polynoe* and *Chaetopterus* are bioluminescents. *Arenicola, Amphitrite, Terebella* and *Serpula* have gills.

Class 2. Oligochaeta (Gk. *Oligos*– few + *chaete* = hair). The body has few setae. There is **cocoon formation** in which ova get fertilized. There is no metamorphosis, *e.g.*, *Pheretima*, (Indian Earthworm), *Lumbricus*, (European Earthworm) *Tubifex, Magascolex* (common earthworm of South India).

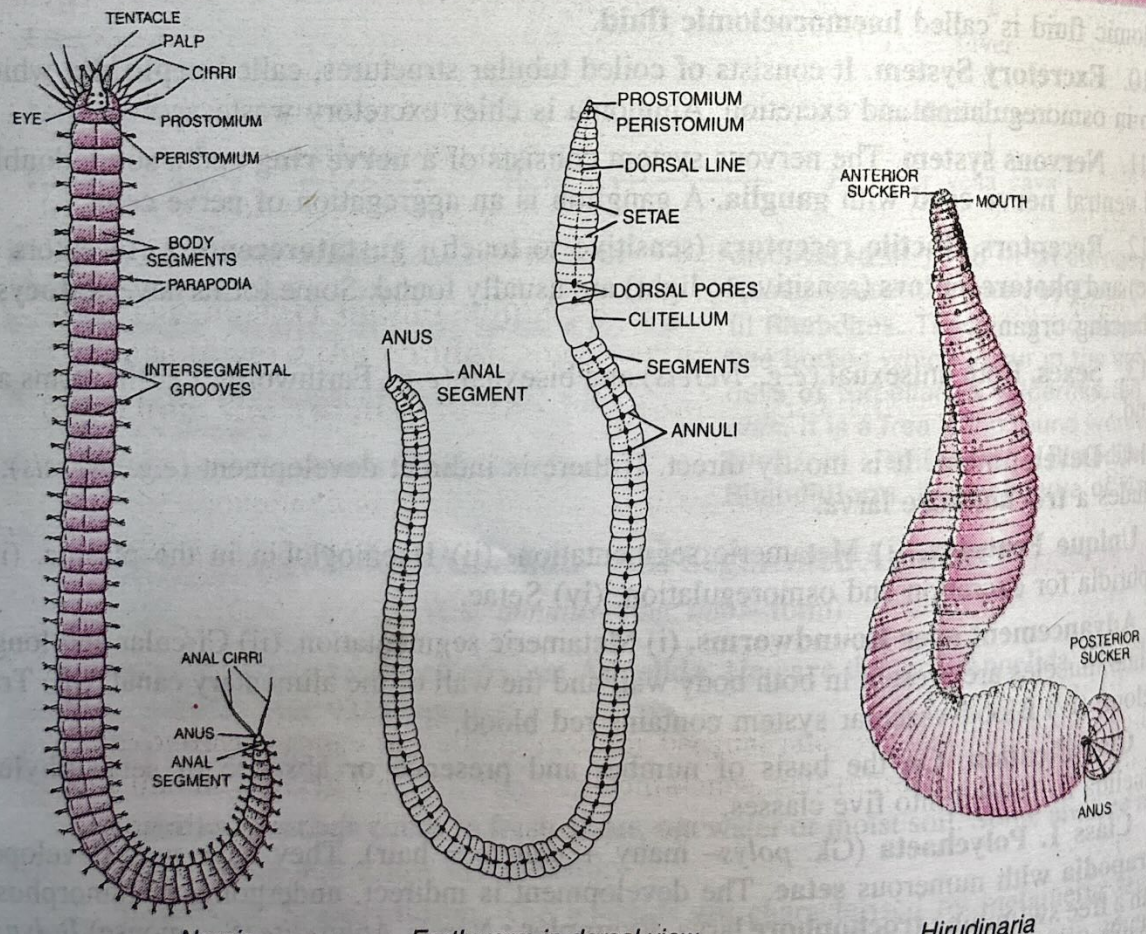
Class 3. Hirudinea (L. *hirudo*– leech). They are ectoparasitic leeches. There are no parapodia or setae. Beneath the muscular layer of the body wall and surrounding the alimentary canal is found **botryoidal tissue** (peculiar connective tissue). Leeches have haemocoelomic system. **Examples :** *Hirudinaria* (cattle leech), *Pontobdella, Hirudo, Acanthobdella.*

Class 4. Archiannelida. External segmentation is faint but internal segmentation is by septa and is complete. Examples *Polygordius, Dinophilus.*

Class 5. Echiurida. These annelids are without external and internal segmentation. Setae are rare. Examples *Bonellia, Echiurus.*

Neanthes* (= Nereis)**. It is commonly called **clam worm** or **sand worm** or **rag worm** which is found on the sea shore in the tubular burrows. Nereis is unisexual and its reproductive phase is called ***Heteronereis. Fertilization occurs in sea-water. During development, a trochophore larva is present. Except the peristomium (first segment) and last anal segment, each segment bears laterally one pair of fleshy projections, the **parapodia**, used in swimming.

***Pheretima* (Earthworm)**. It has been described in detail in Chapter 7A "Structural Organization of Animals".



Nereis. *Earthworm in dorsal view* *Hirudinaria*

Fig. 4.25. Some Annelids.

***Hirudinaria granulosa*— The cattle leech.** It is an ectoparasite on cattle. *Hirudinaria* feeds on blood and hence called **sanguivorous**. The saliva of the leech contains an anticoagulant, called **hirudin** which prevents clotting of blood during blood meal. It is hermaphrodite, but cross-fertilization occurs. It is important to note that the segments 9, 10, 11 develop a *temporary clitellum* during breeding season. The leech bears two **suckers** : anterior and posterior. There are present **five pairs** of **eyes** on the dorsal surface. Some leeches are used as fish bait. Some leeches are used as surgical agents specially for curing diseases such as piles, baldness, etc, which is not correct.

ADDITIONAL INFORMATION

- *Bonellia viridis*. In this marine annelid, sexual dimorphism is very remarkable. Female is about 5 cm. Male is about 0.5mm. Male lives in the female's body.
- **Tubifex** (= **Blood worm**). It is a bright red coloured worm which feeds on the organic matter found in sewage. Its blood contains haemoglobin. Presence of Tubifex indicates sewage contamination.
- In *Pontobdella*, the female shows parental care which guards the eggs for hatching.
- **Chaetopterus** (Paddle worm) It is highly **phosphorescent** and emits blue-green light. Reproduction is usually asexual (by transverse fission). The whole body can be regenerated from a single segment.

Phylum Arthropoda— the Animals with jointed feet or appendages

(Gk. *Arthron*– joint; *Podos*– foot)

Lamarck proposed three classes — *Crustacea, Hexapoda* and *Arachnida*. **Von Seibold** (1845) proposed the term **Arthropoda** and established it as phylum. The phylum Arthropoda includes the *largest number of animals* with 900,000 species. Thus this is the **largest phylum** of kingdom Animalia.

General Characters

1. **Habitat**. They occur on land, in the soil, in sea water, in fresh water and in the bodies of animals and plants as parasites.

2. **Body Form**. It varies considerably. They have jointed legs. The body is segmented externally. The body consists of **head**, **thorax** and **abdomen**.

3. **Body wall**. The body is covered with a thick, tough and non-living chitinous **cuticle**, which forms the **exoskeleton**.

4. **Body cavity**. The true coelom is greatly reduced in adults, and is only represented by the cavities of the reproductive and excretory organs. The body cavity is a **haemocoel** *viz.*, cavity filled with blood.

5. **Digestive tract**. It is complete. The alimentary canal consists of **stomodaeum** (fore gut), **mesenteron** (mid gut) and **proctodaeum** (hind gut).

6. **Blood vascular system**. It is of **open type** *viz.*, blood does not flow in definite vessels. There are present irregular spaces, known as **lacunae** or **sinuses**, filled with blood.

7. **Respiratory organs**. These are **gills** or **book gills** in aquatic forms and **tracheae** or **book-lungs** in terresterial forms.

8. **Excretory organs**. These are either **green glands** or **Malpighian tubules**. In some forms **coxal glands** are excretory organs.

9. **Nervous system**. The annelidian type of nervous system is present, *viz.*, it consists of a nerve ring and a solid double ventral nerve cord with ganglia.

10. **Sense organs**. Sensory organs like antennae and eyes are present. In many arthropods, **compound eyes** are present, in which **mosaic vision** is developed. Some forms also have **statocysts** (balancing organs).

11. **No cilia**. An important feature of the arthropods is the complete absence of the cilia.

12. **Muscles**. The muscles are generally striped, which are capable of rapid action. Unstriped muscles are also found.

13. **Endocrine glands.** Endocrine glands are present which secrete **hormones**. Some arthropods particularly insects excrete **pheromones**. The latter are chemicals which communicate message. Some pheromones act as sex attractants.

14. **Sexes**. Sexes are separate (dioecious) and the **sexual dimorphism** is observed in many forms.

15. **Development**. Fertilization is usually internal. They are mostly oviparous. Development may be direct or indirect. In indirect development there is **metamorphosis**.

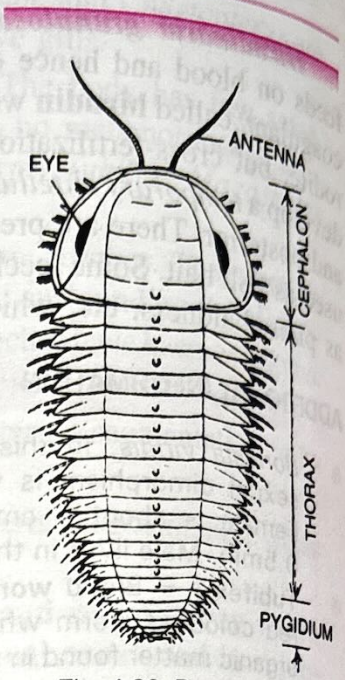


Fig. 4.26. Dorsal side of a *Trilobite*.

16. **Parental care**. It is often seen in many arthropods.

17. **Parthenogenesis.** Development of an egg (ovum) into a complete individual without fertilization by a sperm, is called parthenogensis. Male honey bees (drones) are formed by parthenogenesis.

Examples : Economically important insects — *Apis* (Honey bee), *Bombyx* (Silk worm), *Laccifer* (Lac insect).

Vectors — *Anopheles, Culex* and *Aedes* (all the three are mosquitoes).

Gregarious pest — *Locusta* (Locust)

Living fossil — *Limulus* (King crab).

Trilobites (Fig. 4.26) are fossil arthropods which are over 600 million years old.

Unique Features. (i) Jointed appendages. (ii) Thick exoskeleton. (iii) Compound eyes. (iv) Haemocoel. (v) Antennary glands, Malpighian tubules and coxal glands for excretion and osmoregulation. (vi) Tracheae, gills, book gills, and booklungs as respiratory organs. (vii) Pheromones.

Advancement over Annelids. (i) Distinct head. (ii) Well developed exoskeleton. (iii) Jointed appendages for different functions. (iv) Striped muscles. (v) Endocrine glands and pheromones. (vi) Special respiratory organs such as tracheae, book lungs. (vii) Compound eyes.

Classification. On the basis of body divisions and presence or absence of certain appendages, the phylum arthopoda is divided into seven classes.

Class 1. Crustacea. The body is divisible into **cephalothorax** (head + thorax) and **abdomen**. Dorsally, the cephalothorax is covered by a thick exoskeletal **carapace.** There are present two pairs of antennae and a pair of stalked compound eyes. **Examples :** *Palaemon*, (Prawn), *Astacus* (Cray fish), *Palinurus* (Lobster), *Cancer* (Crab), *Lucifer* (shrimp) *Eupagarus* (Hermit Crab), *Lepus* (Goose barnacle), *Balanus* (Acorn barnacle), *Sacculina* (a parasite on crab), *Oniscus* (Wood louse— terrestrial), *Squilla*, *Daphnia* (Water flea), Cyclops*.

*It possesses a single median eye. It is named after one eyed giant Cyclops of Greek mythology.

Class 2. Chilopoda*[1]. Body is divisible into head and trunk. Each trunk segment bears a pair of legs. The first pair of legs are modified into **poison claws**. There is a single pair of antennae. **Example :** *Scolopendra* (centipede).

Class 3. Diplopoda*[2]. Body is divisible into head, thorax and abdomen. There is a single pair of antennae. Except first thoracic segment, (it does not have legs) each thoracic segment bears a pair of legs, however, each abdominal segment has two pairs of legs. **Example :** *Julus* (millipede).

Differences between Centipedes and Millipedes

Centipedes	*Millipedes*
1. Occur under bricks and stones or in crevices and holes.	1. Occur in damp and shady places.
2. Nocturnal, carnivorous.	2. Herbivorous or saprozoic
3. Body is divisible into head and trunk.	3. Body is divisible into head, thorax and abdomen.
4. Each trunk segment bears a pair of legs. The first pair of legs are modified into poison claws. Total legs are 18-21 pairs.	4. Except first thoracic segment, each thoracic segment bears a pair of legs. However, each abdominal segment has two pairs of legs. Total legs are 70-100 pairs.
5. Collum is absent.	5. First thoracic segment which is without legs, is called **collum**.
6. No stink glands and foul smell.	6. Most abdominal segments contain **stink glands** (= **odoriferous** or **scent glands**). Their secretions are toxic to other animals.
7. Inflict a painful bite with poison claws. **Example.** *Scolopendra*	7. May damage tender plants. **Example.** *Julus.*

Class 4. Insecta (Hexapoda). Body is divisible into head, thorax and abdomen. There is a pair of antennae, and a pair of compound eyes. The thorax consists of three segments with three pairs of legs and usually two pairs of wings. The abdomen may consist of upto eleven segments. **Uric acid** is chief excretory waste. **Examples :** silver fish, cockroach, bedbug, locust, termites, butterflies, rat flea, beetle, wasp, aphid, silk moth, etc.

Class 5. Arachnida. The body is usually divisible into cephalothorax and abdomen. The cephalothorax bears simple eyes and six pairs of appendages (one pair of **chelicerae**, one pair of **pedipalpi** and four pairs of legs). Antennae are absent. Respiratory organs are **book lungs** or tracheae or both. **Examples :** scorpion, spider, tick, mite.

Class 6. Onychophora. Example *Peripatus*.

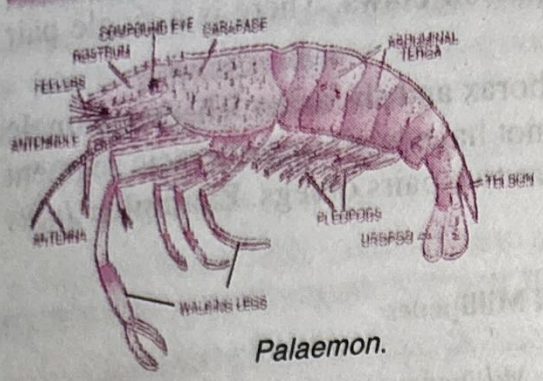
Class 7. Merostomata. Example *Limulus*.

***Palaemon* (Prawn)**. Gills are the chief respiratory organs. The body is divisible into cephalothorax and abdomen. The cephalothorax bears 13 pairs of appendages. The abdomen has 6 pairs of appendages. The appendages are useful in feeding, swimming, balancing etc. The posterior end of abdomen forms a conical **telson**. Prawn is edible.

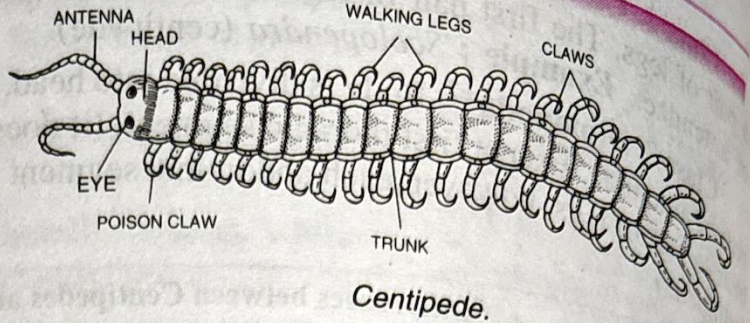
***Cancer* (Crab)**. Five pairs of thoracic legs are present in which first pair of legs forms enormous chelipedes.

***Peripatus* (The walking worm)**. It has characters of phylum Annelida and phylum Arthropoda. Hence it is a "**connecting link**" between Annelida and Arthropoda.

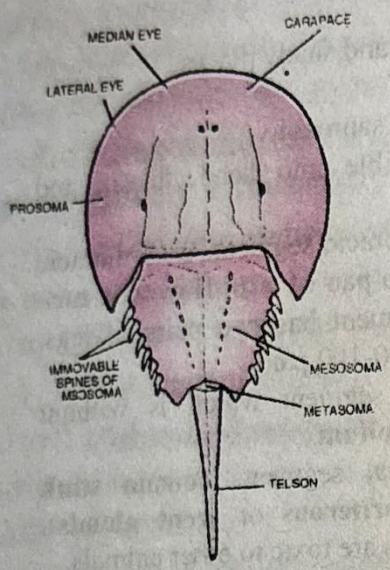
[1 & 2] *Chilopoda and Diplopoda were earlier included in a single class Myriapoda.



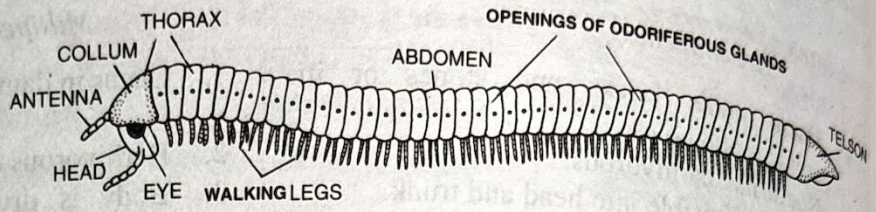
Palaemon.



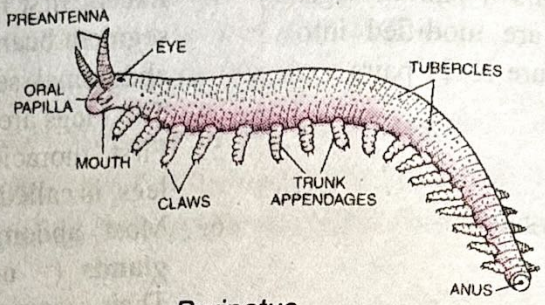
Centipede.



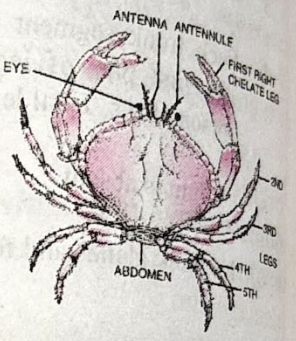
Limulus



Millipede.



Peripatus



Cancer

Fig. 4.27. Some Arthropods

Annelidian characters. (i) Long, Worm-like body. (ii) Segmentally arranged nephridia.

Arthropod characters. (i) Antennae on the head. (ii) Tracheae for gas exchange.

***Limulus* (The king Crab or Horse-shoe crab).** The king crab continues to remain unchanged for the past about 190 million years. It is, therefore, also called "**living fossil**". Excretion takes place through four pairs of **coxal glands**. Respiratory organs are **book gills**.

External Characters of a Typical (generalised) Insect (Fig. 4.28)

The body of an insect is divisible into head, thorax and abdomen. **Head** bears generally compound eyes, antennae and mouth parts. **Thorax** consists of three segments, *viz.*, anterior **prothorax**, middle **mesothorax** and posterior **metathorax**. Each thoracic segment bears a pair of legs. Thus, there are six legs in an insect. Hence an insect is also called **hexapod**. Usually two pairs of wings are present; anterior pair arises from the mesothorax and the posterior pair from the metathorax. **Abdomen** may consist of upto ten or eleven segments. A pair of **anal cerci** generally arises from the posterior end of the abdomen. The latter bears an *anus*, and genital aperture. **Spiracles** are paired openings which lead into tracheae, the respiratory organs.

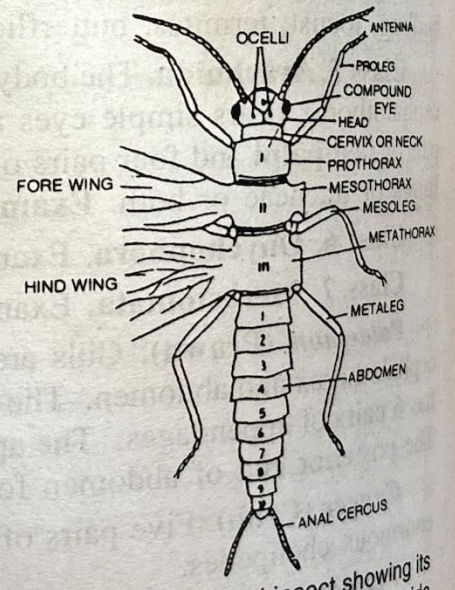


Fig. 4.28. A typical insect showing its various parts. Wings on the right side not shown while on the left side partly shown.

***Lepisma* (Silver fish).** It is common houseold pest, usually found in cool damp places, such as among old

books, under picture frames, wall papers, clothes, etc. It is **wingless.** *Lepisma* does not undergo metamorphosis. The silver fish commonly feeds on starch, and cause considerable damage to books and clothes.

Mayflies. The mayflies are the *shortest-lived insects* and hardly survive a couple of days. They never feed and their alimentary canal is filled with air, so as to increase the buoyancy of the body for the nuptial flight in the evening on a summer day, usually May (hence the name Mayfly). The mayfly larvae live in water and feed voraciously on aquatic vegetation and develop in two or more years, before becoming an adult. The female lays her eggs in water and dies soon afterward.

***Cimex* (Bed Bug).** It lives as ectoparasite and sucks human blood so it is **sanguivorous**. Bed bugs are usually found in crevices of cots and under the mattresses. Sometimes, they show **cannibalism**. The mesothorax is usually hidden by two small **wing pads**, which are the vestigial fore wings. The hind wings are completely absent. It is supposed that the germs of typhoid, plague, kala-azar, tuberculosis, relapsing fever, etc. can be transferred by them.

***Vespa* (Wasp).** They are colonial, polymorphic and social insects, living in the hives. The body is yellowish in colour. They are *trimorphic*. The workers have a powerful sting by which they can inject into the human body causing pain.

***Aphis* (The Aphid).** The aphid sucks plant sap. It excretes 'honey dew' through the **cornicles (honey dew tubes)**. The 'honey dew', being sweet is eaten by ants. The ants domesticate the aphids for this purpose. Such aphids are called "ant cows". The female aphids are *viviparous* and reproduce by *parthenogenesis*. Aphids are serious pests. They damage the plants by sucking their sap.

Beetles. They are mostly pests of crops. The fore-wings are thickened, leathery, hard and opaque, which are called wing covers or **elytra**. They are not used for flight. The order *Coleoptera in which the beetles are placed, is the largest order in the animal kingdom.* Herbivorous beetles feed on vegetables, thus they spoil useful crops. They also spoil stored foodgrains. Some carnivorous beetles feed on aphids, the harmful insects, therefore, they are useful in this respect.

Butterflies. They are diurnal in habit. *Pieris* (**the cabbage butterfly**) lays eggs on cabbage leaves. The larvae are worm-like and called *caterpillars*. They are usually coloured insects. Most of the butterflies are quite destructive, as they feed on crops, orchards, gardens, etc. They are useful in cross pollination.

Locust. There are many locusts but *Schistocerca gregaria* (desert locust) and *Locusta migratria* (migratory locust) have been known from time immemorial. *They are the most destructive of all insects.* Locusts come to India from Pakistan. Locusts are serious plant pests.

***Poecilocerus pictus* (Ak-grasshopper).** Grasshopper is essentially a solitary insect. *Poecilocerus pictus* lives on Ak plants. It feeds on leafy vegetation. Therefore, it sometimes causes serious damage to the crops.

***Pediculus* (Human louse).** *Pediculus humanus* is an ectoparasite of human beings and feeds on their blood. Eyes are poorly developed. Wings are absent. They suck the blood and carry germs of **typhus fever.**

***Xenopsylla* (Rat flea).** *Xenopsylla cheopis* is an ectoparasite of rats and men and feeds on their blood. Wings are absent. *Xenopsylla cheopis* transmits *Bacillus pestis* from rat to man which causes **bubonic plague**.

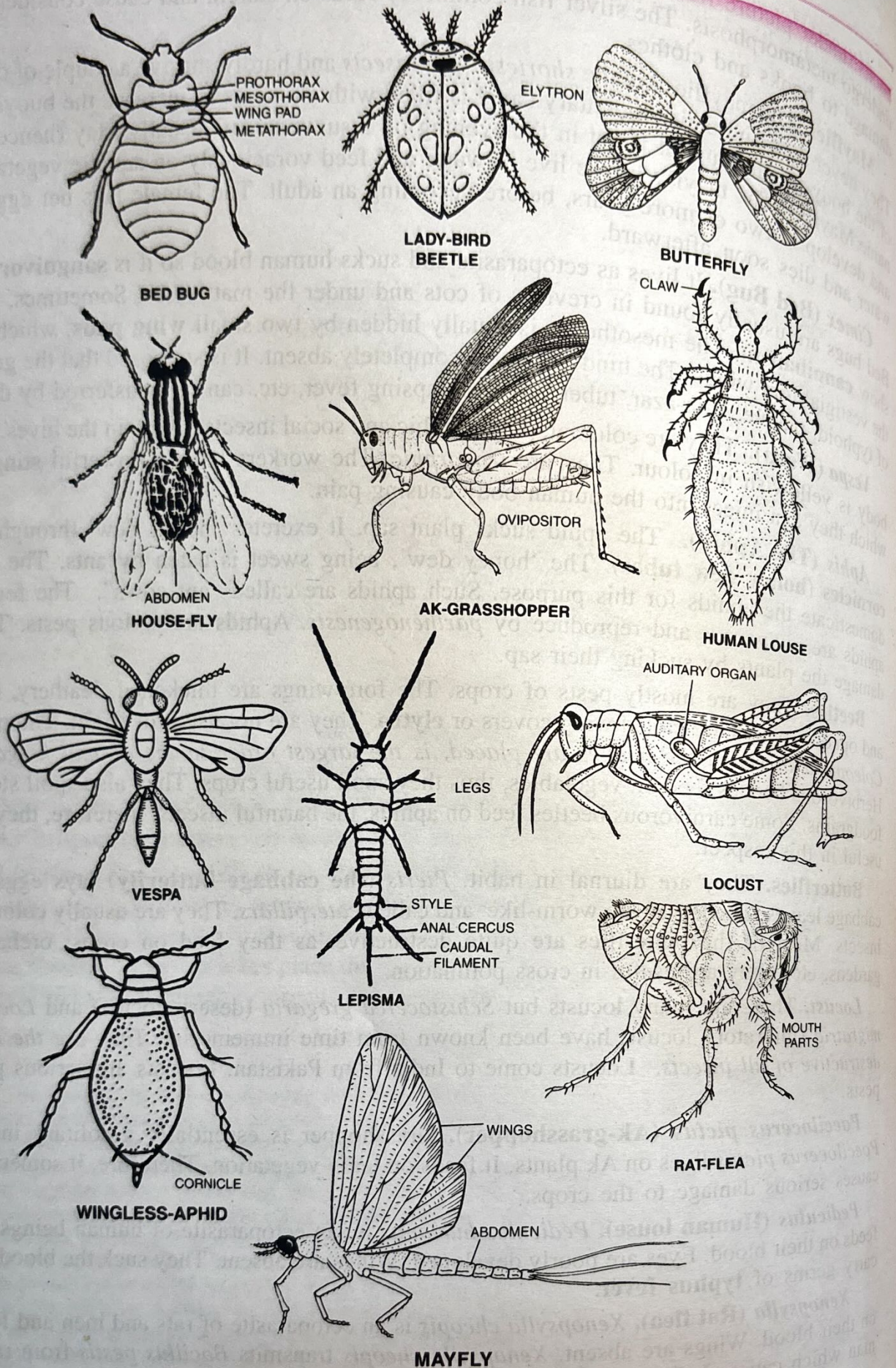


Fig. 4.29. Some insects.

***Musca* (House Fly).** They are **saprophagous** in diet, *viz.*, taking fluid only. If the food matter is solid, like solid sugar, it first pours its saliva over it to dissolve the food matter, then food rises up the food channel due to the suction force created by the muscular pharynx. *Mandibles are absent.* They are very harmful insects because they spread the germs of some dangerous diseases, such as cholera, typhoid, paratyphoid, anthrax, diarrhoea, dysentery, tuberculosis, etc.

Cockroach. It has been described in detail in Chapter 7A– "Structural Organisation of Animals".

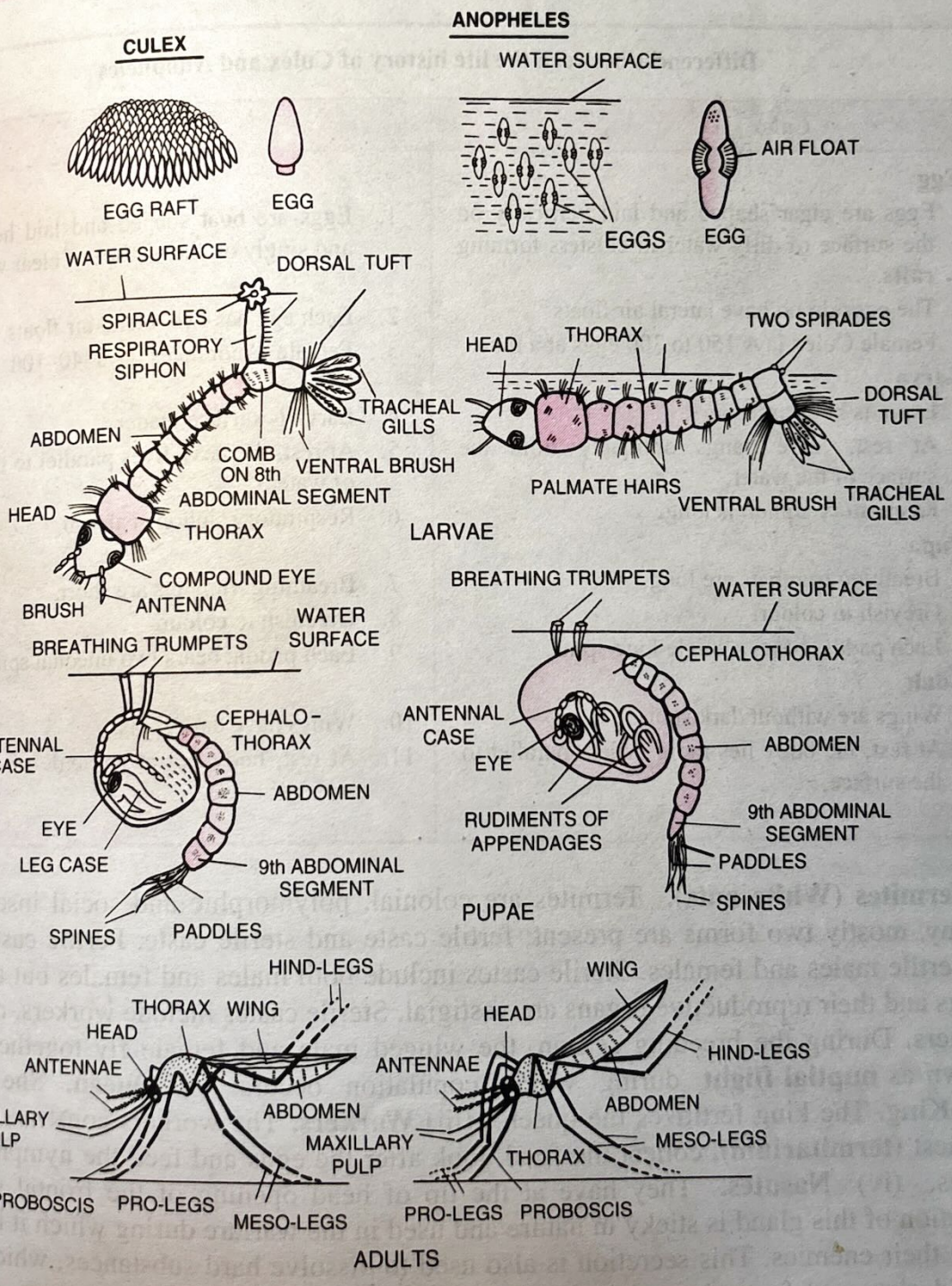


Fig. 4.30. Life history of Culex and Anopheles.

Mosquitoes (Fig. 4.30). The males generally feed on plants juices, while the females feed on blood. Its saliva contains **anticoagulant**. There are present piercing and sucking type of mouth parts. *Mandibles are absent in male mosquito*. The metathorax bears two club-shaped processes known as **halteres** or **balancers**. The **pedicel** (second segment) of the antenna contains **Johnston's organ** which perceives sound vibrations like an auditory organ (hearing organ). *Plasmodium* (Malarial Parasite) which causes **malaria fever** is transmitted by *Culex*. ted by the female anopheles. *Filaria* which causes **filariasis** is transmitted by *Culex*. **Encephalitis** is caused by a virus in man, which results in high fever, headache, drowsiness and inflammation of the brain. This virus is also transmitted by some species of *Culex*. *Aedes* mosquito transmits virus of **Dengu fever, Yellow fever** and **Chikungunya**.

Differences between the life history of Culex and Anopheles

Culex	*Anopheles*
Egg	
1. Eggs are cigar shaped and laid vertically on the surface of dirty water in clusters forming **rafts**.	1. Eggs are boat shaped and laid horizontally and singly on the surface of clear water.
2. The eggs do no have lateral air floats.	2. Each egg has two lateral air floats.
3. Female Culex lays 150 to 300 eggs at a time.	3. Female Anopheles lays 40–100 eggs at a time.
Larva	
4. Larva is bottom feeder.	4. Larva is surface feeder.
5. At rest, larve hangs obliquely from the surface of the water.	5. At rest, the larva lives parallel to the surface of water.
6. Respiratory siphon is long.	6. Respiratory siphon is absent.
Pupa	
7. Breathing trumpets are long.	7. Breathing trumpets are short.
8. Greyish in colour.	8. Greenish in colour.
9. Each paddle bears a single long spine.	9. Each paddle bears two unequal spines.
Adult	
10. Wings are without dark spots.	10. Wings have dark spots.
11. At rest, the body lies more or less parallel to the surface.	11. At rest, body lies at an angle of 45° to the surface.

Termites (White ants). Termites are colonial, polymorphic and social insects. In the colony, mostly two forms are present; fertile caste and sterile caste. Fertile castes include the fertile males and females. Sterile castes include both males and females but are without wings and their reproductive organs are vestigial. Sterile castes include workers, nasutes and soldiers. During the breeding season, the winged male and female fly together which is known as **nuptial flight** during which copulation occurs. (i) **Queen.** She lays eggs. (ii) **King.** The king fertilizes the queen. (iii) **Workers.** The workers construct and repair the nest **(termitarium),** collect the food, look after the eggs and feed the nymph and other castes. (iv) **Nasutes.** They have at the tip of head opening of the frontal gland. The secretion of this gland is sticky in nature and used in the warfare during which it is inflected upon their enemies. This secretion is also used to dissolve hard substances, which workers face during nest formation. (v) **Soldiers.** They defend the colony.

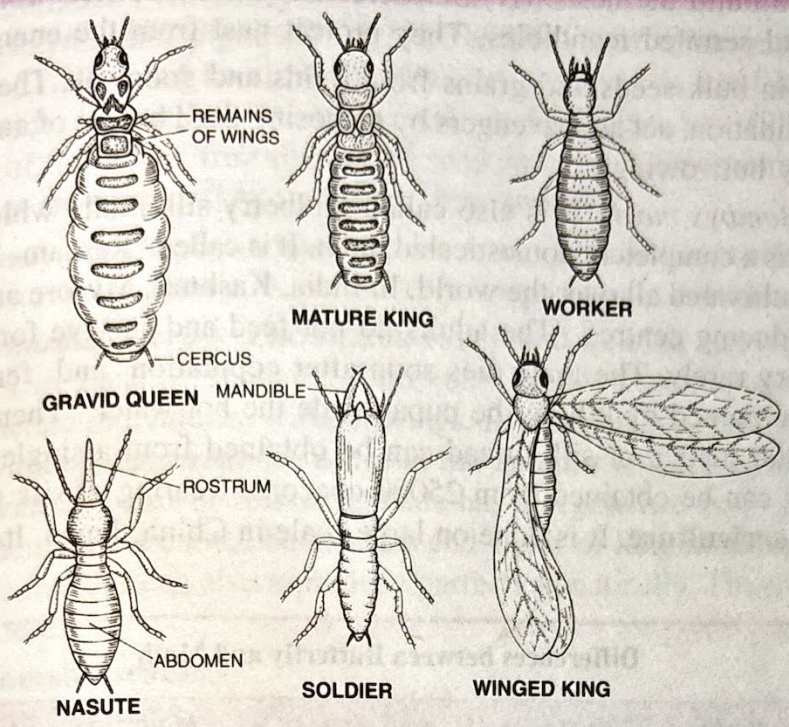


Fig. 4.31. Different castes of termites.

The main food constituent is cellulose, which they obtained from wood or wood work. They are able to digest cellulose with the help of certain flagellates such as ***Trichonympha*** that live in their intestine.

The exchange of food between one insect and the other is called **tropholaxis** which is common in termites.

Ants. Like termites they are social, colonial and polymorphic insects. Tropholaxis is common in the ants. Generally male and female go on a nuptial flight. After mating, the males usually die. The mated females shed their wings and lay eggs in the nests. The main castes of ants are the following. (i) **Queens**. They are fertile females having well developed reproductive organs. Their main function is to lay eggs. They may live up to 15 years in some species. (ii) **Kings**. They are fertile male ants. (iii) **Workers**. Actually they are sterile, wingless females, which are smallest in the nest. The workers take over the feeding of the queen and larvae. They also

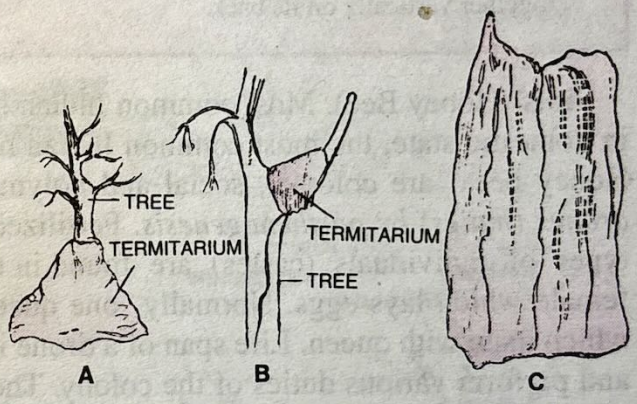


Fig. 4.32 Termite nests. (A) A Termitarium from South Africa (about 90 cm high). (B) A termitarium from Panama. (C) A termitarium from Australia (about 375 cm high).

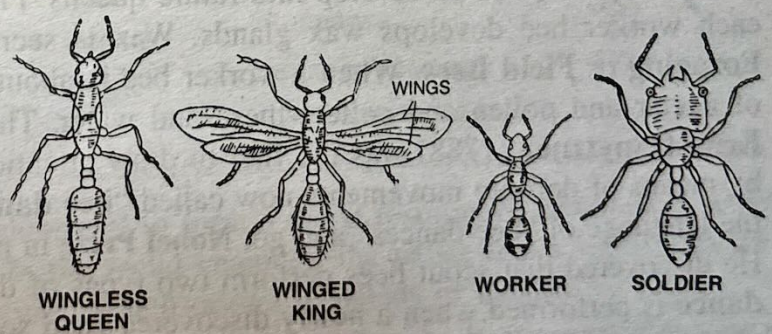


Fig. 4.33. Different castes of ants.

store the food and build the nests. (iv) **Soldiers**. They are modified workers bearing large head and powerful serrated mandibles. They protect nest from the enemies.

Ants destroy in bulk seeds and grains from fields and godowns. Their useful activities are helpful in pollination, act as scavengers by disposing dead bodies of animals, increase the fertility of soil by burrrowing.

Silk Moth (*Bombyx mori*). It is also called mulberry silk moth, which never occurs in the wild state and is a completely domesticated moth. It is called "Resham- Ka- Kira" in Hindi. It is extensively cultivated all over the world. In India, Kashmir, Mysore and Coimbatore are the main silk producing centres. The adults do not feed and survive for two to three days only. They fly very rarely. The male dies soon after copulation and female after laying eggs. The silk is obtained by killing the pupa inside the hot water . Then, the silk thread is wound. About 1000 metres of silk thread can be obtained from a single coccon and about one pound of silk can be obtained from 25000 coccons. Rearing of silk moth for obtaining raw silk is called **sericulture**. It is done on large scale in China, Japan, Italy, France, Brazil, India, etc.

Differences between Butterfly and Moth

Butterfly	*Moth*
1. It is diurnal (active in day).	1. It is nocturnal (active at night).
2. Its antennae are knobbed distally.	2. Its antennae taper distally.
3. When it is at rest, it keeps the wings held together vertically on its back.	3. When it is at rest it keeps the wings held out horizontally.

Apis (Honey Bee). Most common Indian honey bee in wild state is *Apis indica*, however in domestic state, the most common Indian honey bee is *Apis mellifera* (Italian honey bee). Honey bees are colonial, social and polymorphic insects. *Unfertilized eggs develop into drones (males) by parthenogenesis*. Fertilized eggs develop into queens or workers. Three types of individuals (castes) are found in the colony of honey bees; (i) **Queen** is a fertile female which lays eggs. Normally one queen is found in one nest. (ii) **Drones** are males which mate with queen. Life span of a drone is 1–2 months. (iii) **Workers** are sterile females and perform various duties of the colony. The queens are fed by the workers. The abdomen contains the wax glands and the sting. The worker bees of a hive fall into three major castes. (a) **Scavenger** or **Sanitary bees**. For the first three days each worker bee acts a scavenger. (b) **House or Nurse bees.** From the fourth day onwards, each worker bee feeds like a foster mother, with a mixture of honey and pollen. From the seventh day, the **maxillary glands** of a worker bee secrete "**royal jelly**" to feed young larvae, the queen and those older larvae which are destinated to develop into future queens. From the twelfth to the eighteenth day, each worker bee develops wax glands. Wax is secreted in the form of thin scales. (c) **Foraging** or **Field Bees**. When a worker bee is about 15 days old, it explore new sources of nectar and pollen and collect these and water. These bees are also called **scout bees. Ernest Spytzner** (1788) was the first to draw attention to the fact that bees communicate by means of definite movements now called "**bee dances**". **Prof Karl von Frisch** decoded the language of "bee dances" and got **Nobel Prize** in medicine or physiology for it in 1973. He discovered that scout bees perform two types of dances for communication. (i) **Round dance** is performed when a newly discovered food source is close (less than 75 metres) to the hive (ii) **Tail wagging dance** is performed for long distance sources. Life-span of a worker honey bee is 3-4 months.

Economic importance : (i) Honey bees provide honey. Chemical compositon of honey is –ash 01.00% enzyme and pigments 02.21%, maltose and other sugar 08.81%, water 17.20%, dextrose 21.28% and levulose 38.90%. (ii) Bee wax is used in making candles, polishes, toilet goods, cosmetics, electric goods, carbon paper, etc. (iii) Honey bees help in the pollination of flowers of fruit plants and seed crops. (iv) Their sting is poisonous and sometimes fatal to man when they attack in large numbers.

Rearing of honey bees to obtain honey and bee wax is called **apiculture**. A place where bees are kept is known as **apiary**. A person who keeps bees is called **apiarist**.

***Laccifer* (*Tachardia*) *lacca*— Lac Insect.** It is found in thick forest in India, Myanmar (Burma), Ceylon (Sri Lanka), Thailand, Philippine Island, Formosa and East Indies. The females are degenerate individuals, without wings, legs and eyes. The body of the female is soft, ovoid and without segmentation. It has at the anterior end a 2-jointed rostrum and 2-short processes bearing a pair of spiracles. Male has a segmented body divisible into head, thorax and abdomen. The abdomen bears at its end a pair of long **anal hair**. There is sexual reproduction. The females can also reproduce parthenogenetically. The males are active and females are motionless.

During unfavourable season, the females secrete lac to form protective nest for egg-laying upon branches of *Peepal, Dhak, Bargad* and other trees. **Nymphs**, not larvae, hatch-out from the eggs. Lac is scraped from the surface of trees, crushed and sieved to produce **lac dust**. It is used in the manufacture of shellac, varnish, polish, buttons, bangles, toys and some electrical items. A dye is prepared from dead and dried bodies of the females. This dye is used by women folk of our country for *mahavar*. India is the major lac producing country.

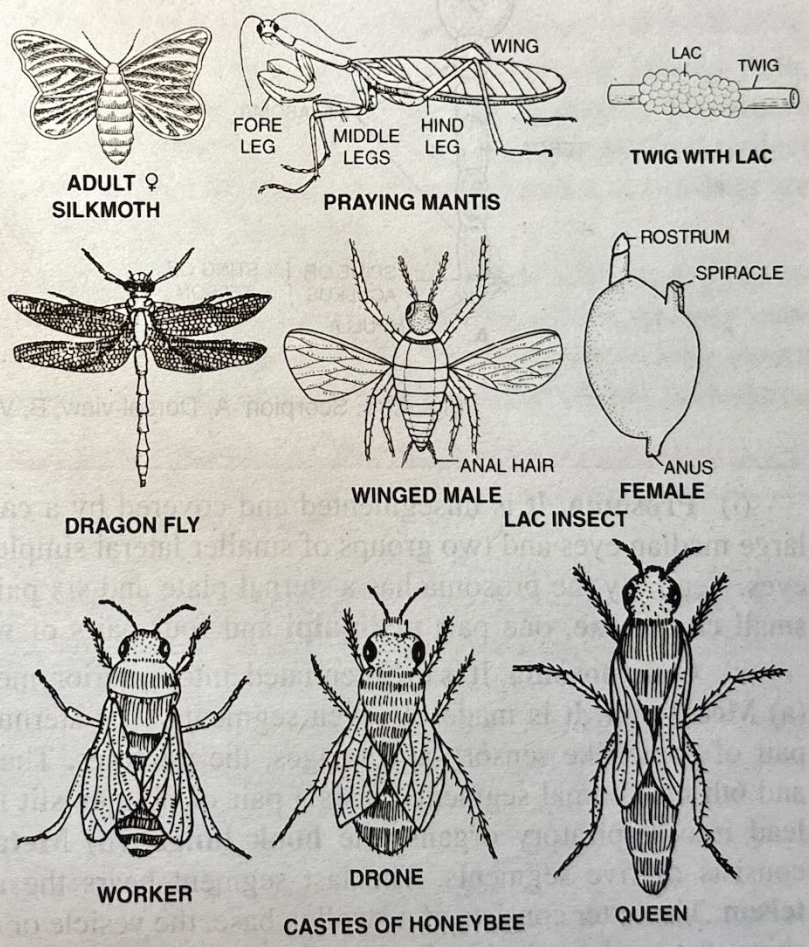


Fig. 4.34. Some useful Insects.

***Sympetrum* (Dragon Fly).** The dragon flies are mostly found in the vicinity of water. They are also called the "mosquito hawks" as their main diet is mosquitoes. Thus, they help in controlling malaria. The female lays eggs in the water. The **naiads** are stout, and their rectum is elongated to form a rectal respiratory chamber in which the gaseous exchange takes place. In the rectal chamber, the naiad draws water and then expels out. This is an unusual structure, which occurs in naiads of dragon fly only.

***Mantis* (Praying mantis).** Praying mantis is usually found on the leafy vegetables, where it feeds on other insects which it captures by means of their prehensile fore-legs. Canni-

balism is very common in these insects. Praying mantis destroys certain harmful insects, so it is a useful insect.

***Palamneus* (Scorpion).** It is **viviparous**. The body is divisible into (i) anterior the *prosoma* and (ii) posterior the *opisthosoma*.

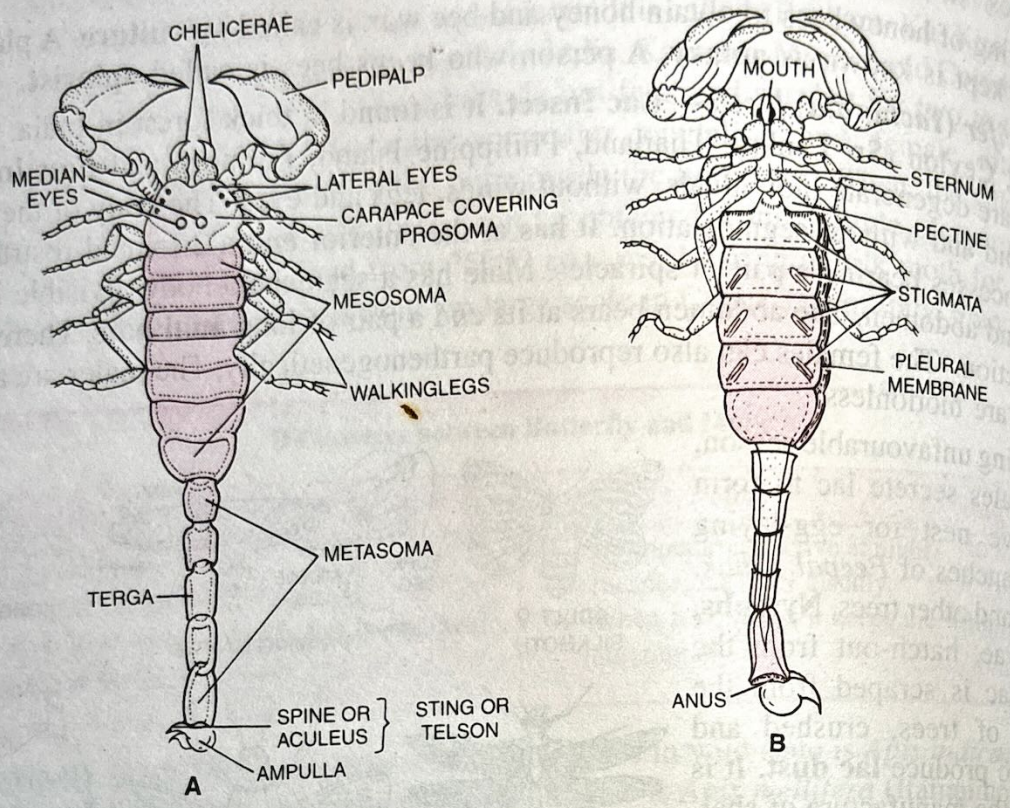


Fig. 4.35. Scorpion. A, Dorsal view; B, Ventral view.

(i) **Prosoma.** It is unsegmented and covered by a **carapace**. The latter bears a pair of large median eyes and two groups of smaller lateral simple eyes, each group comprises three eyes. Ventrally the prosoma has a sternal plate and six pairs of appendages, *i.e.*, one pair of small **chalicerae**, one pair **pedipalpi** and four pairs of **walking legs**.

(ii) **Opisthosoma.** It is differentiated into anterior mesosoma and posterior metasoma. (a) **Mesosoma.** It is made of seven segments. The sternum of the second segment bears a pair of comb-like sensory appendages, the **pectines.** The sternum of each of 3rd, 4th, 5th and 6th mesosomal segments bears a pair of oblique slit like openings the **stigmata**, which lead into respiratory organs, the **book lungs**. (b) **Metasoma.** Its posterior narrow part consists of five segments. The last segment bears the anus and a stinging apparatus or **telson**. The latter consists of a swollen base, the vesicle or **ampulla** and a curved and pointed spine, the **aculeus**. Inside the vesicle lies a pair of **poison glands**, the ducts of which open by a pair of minute apertures at the tip of the spine.

***Aranea* (Spider).** The body is divisible into an anterior cephalothorax and a posterior abdomen. The cephalothorax has six pairs of appendages (one pair of chelicerae, one pair of pedipalpi and four pairs of walking legs). The abdomen is unsegmented, rounded and without telson but has three pairs of spinnerets or spinning organs which produce threads for the construction of spider web. Book lungs and the tracheae are the respiratory organs. Excretory product of spider is guanine. Poisonous spider is *Lectodectus meactans*.

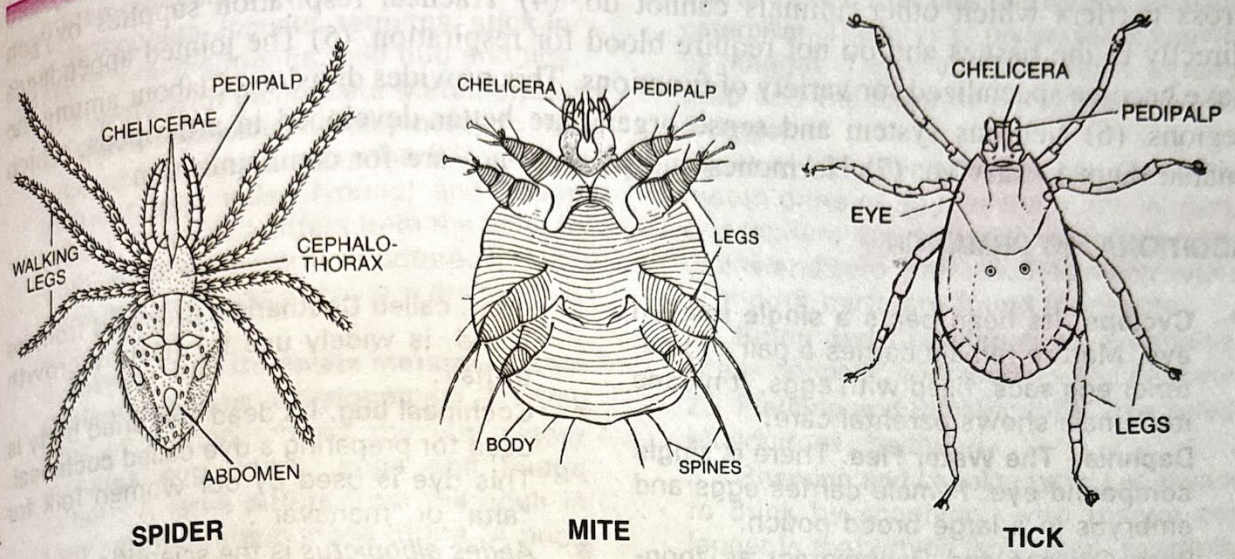


Fig. 4.36. Some Arachnids.

Sarcoptes **(Mite)**. *Sarcoptes scabiei* is a dangerous ectoparasite which attacks man, causing **scabies**, producing severe irritation. The body has transverse striations. The whole body bears long pointed sensory spines. Anterior two pairs of legs are stronger and project beyond the body and provided with terminal stalked suckers. Posterior two pairs of legs are shorter and attached more ventrally and carry long bristles.

Ixodes. **(Sheep tick)**. The body is covered with leathery skin and is without segmentation. Four pairs of legs are segmented. The tarsus of first pair of legs has a sensory cup-shaped **Haller's organ**. Respiration is by spiracles and tracheae. It has blood sucking mouth parts. Its saliva contains an **anticoagulin** which prevents coagulation of blood. It feeds on the blood of sheep.

Differences between Insect and Spider

Insect	*Spider*
1. Body is divisible into head, thorax and abdomen.	1. Body is divisible into cephalothorax and abdomen.
2. It has compound eyes.	2. It has simple eyes.
3. Labrum, labium, hypopharynx, mandibles and maxillae are the mouth parts.	3. Chelicerae and pedipalpi are the mouth parts.
4. Wings are usually present.	4. Wings are absent.
5. Three pairs of legs are present.	5. Four pairs of legs are present.
6. Antennae are present.	6. Antennae are absent.
7. There are no spinnerets.	7. There are present 3 or 4 pairs of spinnerets which occur on abdomen for producing threads for construction of spider web.

Reasons that constitute the arthropods the largest group of animal kingdom

(1) Tough cuticle protects the arthropods against predators and forms jointed exoskeleton for muscles attachment. Being impervious to water, it checks drying-up of the body. This has enabled the arthropods to survive on land in almost any environment. (2) Striated

muscles provide quick movements. (3) The chitinous wings of the insects enable to fly and cross barriers which other animals cannot do. (4) Tracheal respiration supplies oxygen directly to the tissues and do not require blood for respiration. (5) The jointed appendages have become specialized for variety of functions. This provides division of labour among the regions. (6) Nervous system and sense organs are better developed in arthropods, which enable them to survive. (7) Hormones and pheromones are for communication.

ADDITIONAL INFORMATION

- **Cyclops.** Its head bears a **single median eye**. Mature female carries a pair of posterior **egg sacs**, filled with eggs. It means its female shows parental care.
- **Daphnia– The Water Flea**. There is **single compound eye**. Female carries eggs and embryos in a large brood pouch.
- Both *Cyclops* and *Daphnia* act as zooplankton which form important link in the food chain in water.
- **Carcinology.** (i) Study of Crustaceans (ii) Study of cancer.
- **Entomology.** Study of insects.
- **Entomophily.** Pollination by insects.
- **Luminescent Insects** *Photinus, Lampyris* and some other genera bear light producing organs upon their abdomen. These are, therefore, called **fireflies** or **glow worms**. Light is emitted at short intervals by both male and female individuals as a visual signal to attract each other for copulation.
- In India, Urban malaria is transmitted by *Anopheles stephensi*, however, rural vector in India is *Anopheles culicifacies*.
- Usually the larger an animal is, the longer it takes to grow up. One exception is the 17 year *Cicada* (an insect), which spends a very long time as a larva.
- In all insects the interval between two ecdysis (casting of skin) is known as the **stadium** and the form assumed by the young insect during a stadium is called an **instar**.
- Silk glands of the caterpillar of the silk moth are actually modified salivary glands.
- Spider webs are made of silk which is one of the strongest natural substance.
- Loudest insect is male *Cicada*. Sound can be heard upto 4 km. Its absence has given the silent valley of Kerala, its name.
- Monarch butterfly is poisonous.
- Honey bees are regarded the world's most advanced landmine detectors.
- **Blister beetle–Lytta.** This insect is obundantly found in France and Spain. A drug, called **Cantheridin** prepared from its blood, is widely use for healthy growth of hair.
- **Cochineal bug.** Its dead and dried body is used for preparing a dye called **cochineal**. This dye is used by our women folk for "aita" or "mahavar".
- *Aedes albopictus* is the scientific name of Asian tiger mosquito.
- *Sacculina* is a crustacean parasite on crab which spreads a network of tubes inside the crab's body. It has no appendages, mouth and anus but it has a ganglion, a testis and an ovary (being hermaphradite). A peculiarity of this parasite is that if it attacks a male, the crab will change its sex and turn into a female. If it is female crab the ovary gets degenerated and changes into juvenile type. These changes are called **parasite castration**.
- Onisus (wood louse). It is a terrestrial crustacean found under stones, logs, bark etc. which is purely air breather.
- **Astacus** (Cray-fish). It is fresh water crustacean which is relished as food.
- **Phyllium** (Leaf Insect). Its wings are remarkable in having leaf-like colouration and venation. It is perfect example of **mimicry**.
- World Mosquito Day- August 20.
- **Four Major Groups of Insects.** The insects may be divided into four groups on the basis of their mode of development.

  1. **Insects without Metamorphosis (Ametabolous development).** Certain insects, such as silver fish, do not undergo metamorphosis. These insects are most primitive and wingless. There are present three stages in the life history; **egg, young** and **imago** (adult).

  2. **Insects with Gradual Metamorphosis (Paurometabolous development).** In this type of metamorphosis, the life history includes **egg, nymph** (young) and **imago** (Adult). The nymph resembles the adult in its mode of life but differs in structure,

the young being without wings. Gradual metamorphosis occurs in cockroaches, grasshoppers, locusts, termites, stick insects, praying mantis, bed bug and lice.

3. **Insects with Incomplete Metamorphosis (Hemimetabolous development).** In this type of metamorphosis, the life history includes **egg, naiad** (young) and **imago** (adult). The naiad differs from the adult in both mode of life and structure. Incomplete metamorphosis occurs in dragon flies and may flies.

4. **Insects with Complete Metamorphosis (Holometabolous development).** In this type of metamorphosis the life history includes **egg, larva, pupa** and **imago** (adult). A larva differs from the adult in form, structure and mode of life. A pupa is an inactive stage. The latter is transformed into an adult by radical changes. Complete metamorphosis occurs in butterflies, moths, beetles, house flies, mosquitoes, fleas, honey bees, ants and wasps. The larva of butter flies and moths is called **caterpillar**. The larva of houseflies is known as **maggot**. The larva of beetles is termed **grub** and the larva of mosquito is called **wriggler**.

Types of Mouthparts in Insects. Generally mouth parts of an insect are one labrum, one labium, one hypopharynx, two mandibles and two maxillae. Following types of mouth parts are found in insects.

1. **Biting and Chewing type.** Examples: Grass-hoppers, cockroaches and crickets.
2. **Piercing and Sucking type.** Examples: Mosquitoes, bedbugs.
3. **Chewing and Lapping type.** Lap means to drink by scooping with tongue and lapper is that which laps liquid. Example: Honey bees.
4. **Sponging type.** Example: House fly.
5. **Siphoning type.** Examples: Butter flies and moths.

Common Human Diseases Transmitted by Insects

	Insect Vectors	*Diseases Transmitted*
1.	**Flies**	
	(i) Housefly	Typhoid, Diarrhoea, Dysentery, Cholera, Tuberculosis, Trachoma, Conjunctivitis, Amoebiasis, Poliomyelitis (Polio).
	(ii) Sandfly	Kala-azar, Oriental Sore
	(iii) Tse tse Fly	African Trypanosomiasis (African sleeping sickness)
2.	**Ratflea**	Bubonic Plague.
3.	**Mosquitoes**	
	(i) *Anopheles*	Malaria
	(ii) *Culex*	Filariasis (Elephantiasis), Encephalitis
	(iii) *Aedes*	Yellow Fever, Dengue Fever, Chikungunya and Encephalitis.
4.	**Lice**	Trench Fever, Relapsing Fever, Epidemic Typhus fever.
5.	**Triatomid Bugs**	Chagas' Disease (South American Trypanosomiasis— South American Sleeping Sickness)

Phylum Mollusca— The Soft Bodied Animals

(L. *Molluscs*– soft)

Johnston gave the term mollusca. Phylum Mollusca is the **second largest** *animal phylum* which includes over 60,000 species.

General Characters

1. **Habitat**. They are mostly marine. Many, however, occur in fresh water and some even in damp soil.

2. **Body Form**. The body of molluscs is unsegmented with a distinct **head, muscular foot** and **visceral hump**. *Neopilina* is a segmented mollusc.

3. **Symmetry**. They usually show bilateral

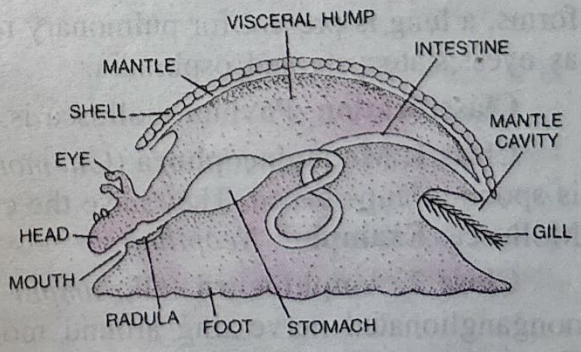


Fig. 4.37. Body plan of molluscs (Hypothetical).

symmetry. In some molluscs like *Pila,* due to **torsion** (twisting) during growth, the adults become asymmetrical.

4. **Shell.** Shell is secreted by mantle. It is made up of calcium carbonate. Shell may be external (*e.g.*, most of molluscs), internal (*e.g.*, slug, cuttle fish, squid) or absent (*e.g.*, *Octopus*).

5. **Mantle (Pallium).** It is a thin, fleshy fold of dorsal body wall more or less covering the body. It encloses a space, which is called **mantle cavity** (= pallial cavity).

6. **Body wall.** Single layered epidermis is usually ciliated. Muscles are unstriped and occur in bundles.

7. **Body cavity.** Coelom is greatly reduced. It is restricted to pericardial cavity (space around the heart), and to small spaces within kidneys and gonads (testes and ovaries). Spaces amongst the viscera (soft organs) contain blood and form **haemocoel.**

8. **Digestive tract.** It is complete.

9. **Blood vascular system**. It is open type. It includes dorsal heart, arteries that open into sinuses (spaces) and veins. Blood is usually blue due to the presence of a *copper-containing blue respiratory pigment* called **haemocyanin**. Among the molluscs, cuttle fish are exceptional in having closed blood vascular system.

10. **Respiratory organs**. These are gills (**ctenidia**), mantle and **pulmonary sac** (in semiterrestrial form).

11. **Excretory organs**. Excretory organs are one or two pairs of sac- like kidneys. Gills are also excretory in function. Ammonia is chief excretory matter.

12. **Nervous System**. The nervous system comprises paired **cerebral, pleural, pedal** and **visceral ganglia** joined by the nerve connectives and commissures. Connectives connect dissimilar ganglia, however, commissures connect similar ganglia.

13. **Sense Organs**. In many molluscs, eyes are present over stalks called **ommatophores**. **Statocysts** (balancing organs) may be present. **Osphradium** is present in some molluscs for testing chemical and physical nature of water.

14. **Sexes.** The sexes are generally separate but some are hermaphrodite.

15. **Development.** They are oviparous. The development is either direct or indirect (metamorphosis). When the development is indirect, it includes a characteristic larva, **veliger, trochophore** or **glochidium**. Asexual reproduction is absent.

Unique Features. (i) Mantle covers the body. (ii) Mantle may be surrounded by shell. (iii) Nervous system consists of cerebral, visceral, pleural and pedal ganglia.

Advancement over Annelids. (i) Shell is present in many individuals. (ii) In some forms, a lung is present for pulmonary respiration. (iii) Better developed sense organs such as eyes, statocysts and osphradia.

Classification. Phylum mollusca is divided into six classes.

Class 1. Monoplacophora (Gk. *monas*– one, *plax*– plate, *pherein*– bearing). The shell is spoon or cup-shaped. They have the characters of both the phylum Annelida and phylum Mollusca. **Example :** *Neopilina.*

Class 2. Amphineura (Gk. *amphi*– both + two *neuron* = nerve). There is present a nonganglionated nerve ring around mouth with two pairs of interconnected nerve cord. **Examples :** *Chaetopleura (Chiton).*

Class 3. Scaphopoda (Gk. *scapha*– boat, *podos*– foot). Shell is tubular and open at both ends. **Example :** *Dentalium.*

Class 4. Gastropoda (Gk. *gaster*– belly, *podos*– foot). Shell is made up of one piece. The early embryo is symmetrical but during development the body twists showing **torsion** so that the body becomes asymmetrical. It includes the *largest number of molluscs e.g., Pila, Limax, Cypraea* (Cowrie), *Helix* (garden snail), *Aplysia* (sea hare), *Doris* (sea lemon), *Limnaea*, (pond snail), *Planorbis, Patella* (true limpet), *Turbinella* (Shankh), *Creseis* (Sea butterfly).

Class 5. Pelecypoda or Lamellibranchiata or Bivalvia (Gk. *pelekus– hatchet, podos–* foot). Shell is made up of two halves. **Examples :** *Unio*, *Mytilus* (Sea mussel), *Teredo* (shipworm), *Ensis* (razor shell or razor clam), *Solen* (razor fish or razor shell), *Ostrea* (edible oyster), *Pecten* (scallop), *Pinctada* (Pearl oyster).

Class 6. Cephalopoda (Gk. *kephale*– head, *podos*– foot). Head and foot regions are combined and modified into a structure which has eyes and eight tentacles, hence the name cephalopod or 'head foot'. Cephalopods are regarded at the top of invertebrates evolution in terms of learned behaviour they exihibit. Shell is external (*Nautilus*), internal (*Sepia*) or absent (*Octopus*). **Examples :** *Sepia*, *Loligo*, *Octopus, Nautilus* (Pearly nautilus). Some cephalopods are the largest invertebrates.

Evolutionary Precursor of Molluscs. A "living fossil" named *Neopilina* discovered in 1952 from the pacific ocean, shows metameric segmentation which is not a characteristic of molluscs. *Neopilina* has 8 pairs of muscles, 5 or 6 pairs of gills, and 5 pairs of nephridia. Metameric segmentation and presence of the trochophore larva in both annelids and molluscs suggest that molluscs have descended from the annelids. Thus, the annelids are the evolutionary precursor of molluscs. *Neopilina* is a **"connecting link"** between Annelida and Mollusca.

***Chiton*— The Coat of Mail Shell.** Chiton is marine and found attached to rocks by its foot. The shell consists of a row of eight plates.

***Dentalium*— The Elephant's tusk-shell.** It is a marine mollusc. *Dentalium* is found burrowing in sand. The shell is slightly curved, tubular and opens at both the ends. There are present filamentous tentacles called the **captacula**, which are useful in feeding.

***Unio* (Fresh Water Mussel).** It is found in rivers, lakes and ponds. The animal is omnivorous feeding on microscopic organisms. Its larva lives as parasite on fish. Its shell consists of two halves, called the **valves**. A whitish elevation in each valve is called **umbo**. The **lines of growth** indicate the age of the individual. There are present two siphons posteriorly. It acts as scavenger and keeps water clean. Its shell yields an excellent quantity of lime. The shells of the fresh water mussels are used in the manufacture of buttons.

***Pila* (Apple snail).** It inhabits ponds, paddy fields, sometimes streams and rivers. It is chiefly herbivorous and feeds on aquatic plants like *Pistia* and *Vallisneria*. It leads an **amphibious** life respiring by means of gill in water and by a plumonary sac an land. Thus it is adapted for both aquatic and terrestrial life. The mouth or aperture of the shell is closed by a flat and oval plate, the **operculum**. Pila has **osphradium** which is meant for testing chemical and physical nature of water. The buccal cavity of *Pila* contains a rasping organ, the **radula**, with transverse rows of teeth for cutting the grasses.

***Limax* (Grey Slug).** It is terrestrial and is abundantly found in gardens, cultivated lands and over damp soil. It is nocturnal and herbivorous. *Shell is internal.* It is a hermaphrodite animal. The slug is a plant pest. It damages seedlings, tender shoots and leaves.

***Sepia*— (Cuttle fish).** It is a marine and a good swimmer. In male the left arm is spoon shaped and is called **hectocotylized** which is used to tranfer sperms into the female. *The shell is internal.* A pear-shaped **ink-sac** containing the ink-like fluid is present. When the

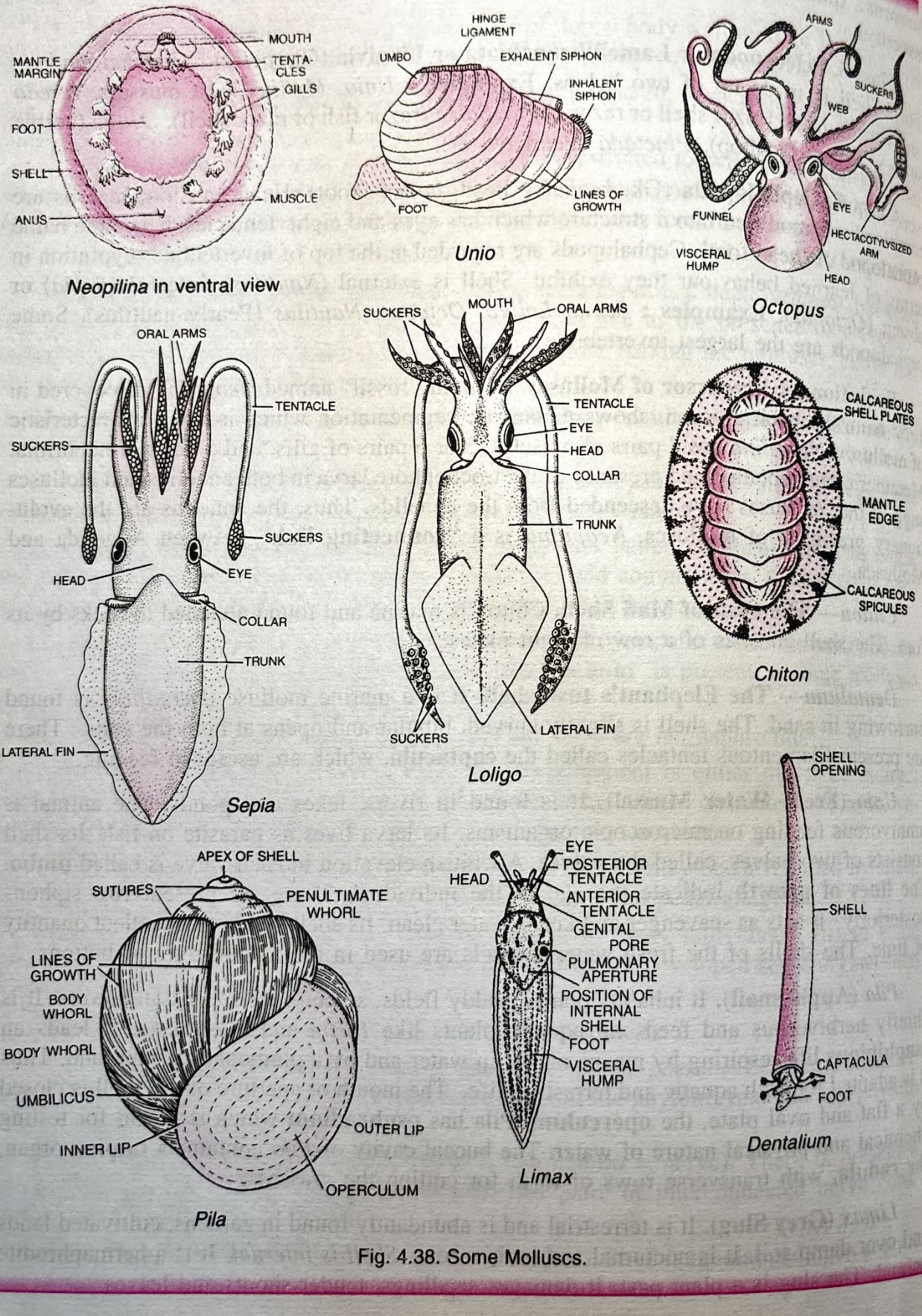


Fig. 4.38. Some Molluscs.

animal is attacked ink-like fluid is ejected through the funnel to form a smoke cloud. Sepia is edible. Sepia ink obtained from this animal is used by artists. The shell of sepia is used as a source of calcium for pet birds.

***Loligo* (Squid).** Like Sepia, it is also found in the warm seas. It also ejects a dark ink to form a smoke cloud to escape from the enemy. Its body resembles that of *Sepia* in form except that it is narrower than that of *Sepia*. It also has *internal shell. Largest living invertebrate is* **giant squid** (*Architeuthis*) upto 18 meters long. *Loligo* is edible. *The giant squid has the largest eye in the animal kingdom.*

***Octopus* (Devil fish).** It is also marine. It kills its prey with poisonous saliva. One of the arms of male is spoon shaped and is called **hectocotylized** which is used to transfer sperms into the female. *The shell is absent. Octopus* ejects an inky fluid in water and forms a screen for defence from its enemies. *Octopus* can change its colour.

ADDITIONAL INFORMATION

- **Pearl formation**. Best quality pearls are obtained from pearl Oyster (*Pinctada vulgaris, P. margaritifera*). It is sedentary mollusc which is now reared artificially. The shell is opened and a fine silica or other particle is introduced between the mantle and the shell. The mantle starts secreting nacre over the foreign particle. In a few years (usually seven) it grows to the size of a pearl. The same is extracted from the oyster. Pearl formation was introduced in Japan by **Mikimoto**. Japan has surpassed all other countries in pearl production.

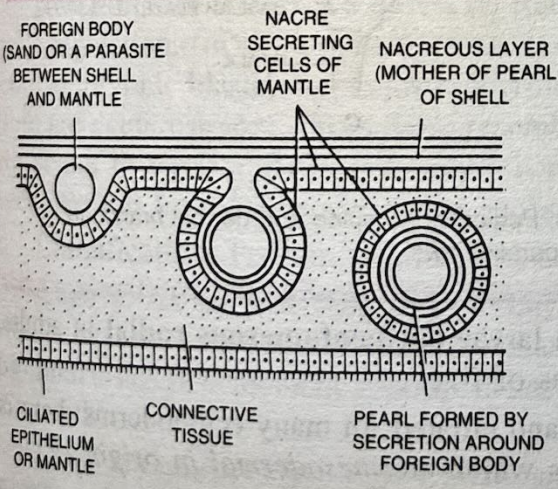

FOREIGN BODY (SAND OR A PARASITE BETWEEN SHELL AND MANTLE
NACRE SECRETING CELLS OF MANTLE
NACREOUS LAYER (MOTHER OF PEARL OF SHELL
CILIATED EPITHELIUM OR MANTLE
CONNECTIVE TISSUE
PEARL FORMED BY SECRETION AROUND FOREIGN BODY

Fig. 4. 39. Stages in pearl formation.

- In *Unio* rectum passes through heart
- *Cypraea* is commonly known as 'Cowrie'. Cowrie shells are used in India in an indoor game, called 'chowpad'.
- **Organs of Bojanus** refer to the Kidneys of the fresh water mussel.
- **Malacology**— Study of molluscs.
- **Conchology**— Study of shells of molluscs.
- Molluscs with internal shell- *Limax, Aplysia, Sepia, Loligo.*
- **Molluscs without shell** — *Doris, Octopus*.
- Ammonites are fossil shell remains of cephalopods.
- **Shell fishes**. A shell fish has a shell in two halves. Examples : mussels, oysters, etc. They are molluscs and are used for food.
- **Ordovician Period**. "Age of invertebrates" (also called "Age of Giant Molluscs").
- Cephalopods (*e.g.*, Squid and Octopus) are some of most intelligent invertebrates.
- **Aplysia (Sea hare)** feeds mainly on the sea weeds.
- **Nautilus** is commonly called as **Pearly Nautilus**. It is used extensively for ornamental purposes.

Phylum Echinodermata— the Spiny Skinned Animals

(Gk. *echinos*– spines; *derma*– skin/covering)

Jacob Klein (1738) introduced the name "**Echinodermata**". About 6000 species belong to the phylum Echinodermata.

General Characters

1. **Habitat**. *All existing echinoderms are marine*. They generally live at sea bottom. Some are pelagic (free swimming in open water) and a few are sessile (attached to the substratum).

2. **Body Form**. It varies considerably. The body is star-shaped, spherical or cylindrical. It is unsegmented. The body lacks head.

3. **Spines and Pedicellariae**. Many echinoderms bear spines and pincer-like **pedicellariae**. The **spines** are protective in function. The pedicellariae keep the body surface clear of debris and minute organisms.

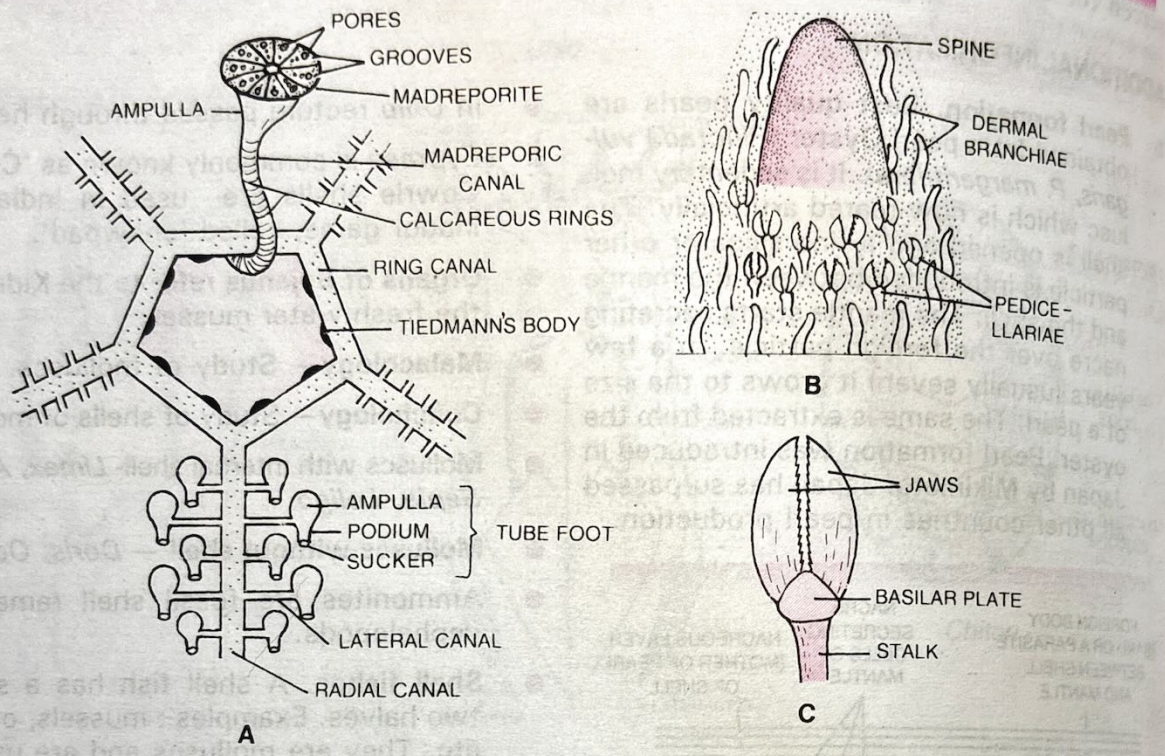


Fig. 4.40. A, Water vascular system of star fish; B, Pedicellariae spine and dermal branchae. C, Pedicellaria with parallel jaws.

4. **Symmetry**. The symmetry is bilateral in larvae but **pentamerous radial** in adults, *i.e.*, body parts are arranged in fives or multiples of five.

5. **Body Wall**. Epidermis is single layered and ciliated. In many echinoderms there is **endoskeleton** of calcareous plates in the dermis which are *mesodermal in origin*.

6. **Body Cavity**. There is a true **enterocoelic coelom**.

7. **Ambulacral System (= Water Vascular System)**. *Presence of ambulacral system is the characteristic feature of phylum echinodermata*. A perforated plate called **madreporite** is present in this system. The pores of the madreporite allow water into the system. **Tube feet** of this system help in locomotion, capture of food and respiration. Water vascular system is of *coelomic origin*.

8. **Digestive Tract**. It is usually complete. Brittle stars have incomplete digestive tract.

9. **Haemal** and **Perihaemal Systems**. Instead of blood vascular system, there are present haemal and perihaemal systems which are of *coelomic origin*. Thus the so called

circulatory system is open type and includes haemal and perihaemal systems. The so called blood is often without a respiratory pigment. There is no heart.

10. **Respiratory Organs**. Gaseous exchange occurs by **dermal branchae** or **papulae** in star fishes, **peristominal gills** in sea urchins, **genital bursae** in brittle stars, and **cloacal respiratory trees** in holothurians. Exchange of gases also takes place through tube feet.

11. **Excretory Organs**. Specialized excretory organs are absent. Nitrogenous wastes are diffused out via gills. Ammonia is chief excretory matter.

12. **Nervous System**. It consists of a **nerve ring** and **radial nerve cords**. Brain as such is absent.

13. **Sense Organs**. They are poorly developed.

14. **Sexes and Fertilization.** Except a few individuals, the sexes are separate. There is no sexual dimorphism. Fertilization is usually external.

15. **Asexual Reproduction**. Some forms reproduce asexually by self-division.

16. **Autotomy** and **Regeneration**. Phenomena of autotomy and regeneration are often well marked in echinoderms.

17. **Development**. The development is indirect and includes a ciliated, bilaterally symmetrical larva that undergoes metamorphosis to change into the radially symmetrical adult. Different larval forms are found which are mentioned in the classes of Echinodermata.

Unique Features. (i) Presence of spines and pedicellariae. (ii) Ambulacral system (water vascular system). (iii) Haemal system. (iv) Mesodermal endoskeleton of calcareous plates. (v) Bilateral symmetry in the larva and radial symmetry in the adult.

Degenerate Characters. (i) Lack of head. (ii) Simple sense organs. (iii) Incomplete digestive tract in some forms. (iv) Reduced circulatory system. (v) Absence of excretory system.

Resemblance with Chordates. (i) Radial and indeterminate cleavage. (ii) Gastrulation by invagination. (iii) Mouth derived as an ectodermal invagination. (iv) Adult anus derived from embryonic blastopore. (v) Mesodermal endoskeleton. (vi) Enterocoelous coelom. (vii) Both are deuterostomes. From these resemblances, it is clearly proved that the Echinoderms are nearer to the Chordates than any other group. It also indicates that the chordates have been evolved from Echinoderm-like ancestors.

Classification. Phylum Echinodermata is divided into five classes.

Class 1. Asteroidea (Gk. *aster*– star, *eidos*– form). Body is star-like. Five arms are usually present which are not sharply marked off from the central disc. Larval forms are **Bipinnaria** and **Brachiolaria. Examples :** *Asterias* (Star fish), *Pentaceros* (Star fish), *Astropecten* (Star fish).

Class 2. Ophiuroidea (Gk. *Ophis*– snake, *Oura*– tail, *eidos*– form). Body is star-like. Arms are sharply marked off from the central disc. Ambulacral grooves are absent. Pedicellariae are absent. Larval form is **Ophiopluteus. Examples :** *Ophiothrix* (brittle star), *Ophioderma* (brittle star), *Ophiocoma* (brittle star), *Ophiura* (brittle star).

Class 3. Echinoidea (Gk. *echinos*– hedgehog, *eidos*– form). Body is globular or disc-like. Biting and chewing apparatus with teeth called **Aristotle's Lantern** is present. Ambulacral grooves are absent. Larval forms are **Pluteus** and **Echinopluteus. Examples :** *Echinus* (sea-urchin), *Clypeaster* (cake urchin), *Echinarachinus* (sand dollar), *Echinocardium* (heart urchin).

Class 4. Holothuroidea (Gk. *Holothurion*– sea cucumber, *eidos*– form). Body is elon-

gated and cylindrical. Oral end has mouth surrounded by tentacles. Ambulacral grooves are absent. Spines and pedicellaria are absent. Larval forms are **Auricularia** and **Doliolaria**. **Examples :** *Holothuria* (sea cucumber), *Cucumaria* (sea cucumber).

Class 5. Crinoidea (Gk. *Crinon*– lily, *eidos*– form). Body has a central disc which is attached to the substratum. *Arms are branched.* Spines and pedicellariae and madreporite are absent. Larval form is **Doliolaria.** They are commonly called feather stars or sea lilies. **Example :** *Antedon* (feather star), Sea lilies.

Asterias **(Star Fish).** It possesses great power of regeneration and shows autotomy. At the terminal end of each ambulacral groove lies a bright red ***eye***. The aboral surface bears many stout **spines** distributed irregularly. In between the spines, there are present soft **dermal branchiae**. They act as respiratory and excretory organs. In between two arms near the anus, there is present a perforated circular plate, the **madreporite.** There are present microscopic pincer-like structures known as **pedicellariae**. They also act as organs of offence.

Their dried skeletons containing calcium and nitrogen are crushed and used as fertilizers. They feed upon dead animals and their fragments, therefore, help in cleaning the sea floor. They destroy pearl oysters causing much harm to the pearl industry.

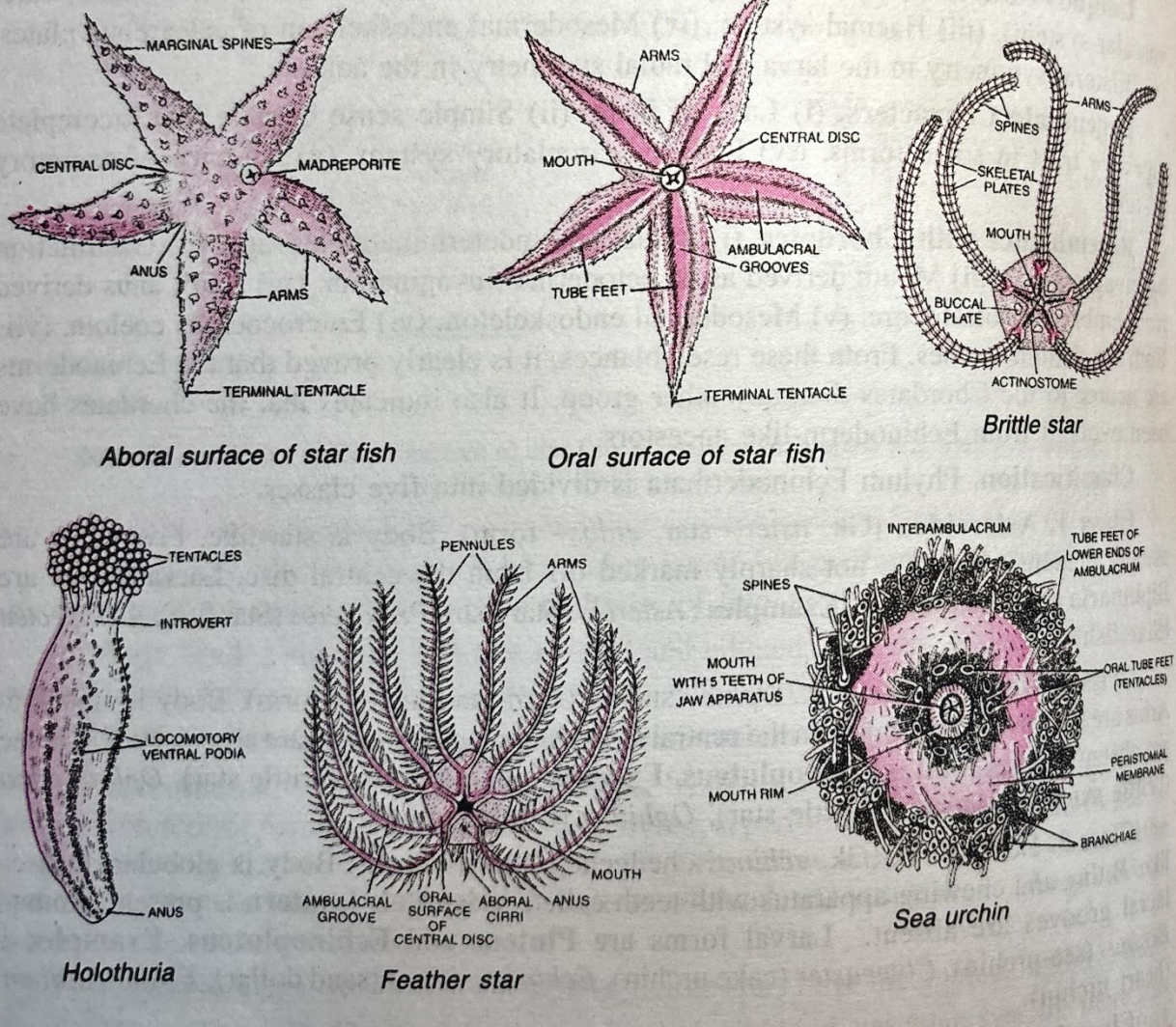


Fig. 4.41. Some Echinoderms.

***Ophiothrix* (Brittle star).** Brittle stars also swim like snake with their arms. Anus is absent.

***Echinus* (Sea urchin).** It moves with the help of spines. The sea urchin has a masticatory apparatus, called **Aristotle's Lantern** because of its resemblance to ancient Greek ship lantern. It is formed by five strong and sharp teeth.

***Holothuria* (Sea cucumber).** The sea cucumbers respire by **respiratory trees** in the cloaca. For this, water is drawn in and expelled through the anus alternately. The mouth is anterior and is surrounded by tentacles.

***Antedon* (Feather star).** It has great power of autotomy and regeneration. The body comprises a cup shaped central **disc** and five slender arms. Each arm is bifurcated, bearing a row of **pinnules** on each side. It is attached to the substratum.

ADDITIONAL INFORMATION

- Endoskeleton in echinoderms is unique in being a mesodermal structure instead of ectodremal as in other invertebrates.
- **Cuverian Organs**. In *Holothuria*, the lower branches of the respiratory trees are modified into **Cuverian organs** which secrete a sticky secretion for defence.
- Star fishes do very well with no brain at all.
- ***Auricularia*** is connecting link between nonchordata and chordata.

Phylum Hemichordata

(Gk. *hemi*– half, *chordata*– notochord)

Due to some similarities with chordates, some workers (**Bateson**, 1885) considered Hemichordata as a subphylum under phylum chordata. But, on grounds of its general organization, recent scientists, like **Van der Horst** (1939), **Dawydoff** (1948), **Marcus** (1958) and **Hyman** (1959), have given it the status of a phylum under nonchordata. The name "Hemichordata" is, however retained for the group.

General Characters

1. **Habitat**. They mostly live in burrows and are *exclusively marine*.
2. **Body Form**. Body is soft, worm-like and is divisible into *proboscis, collar* and *trunk*.
3. **Body wall**. It is with a single layered epidermis.
4. **Coelom**. The hemichordates are *enterocoelous*.
5. **Stomochord.** It is a *hollow outgrowth*, arises from the roof of the buccal cavity, called "buccal diverticulum". It is present in the proboscis.
6. **Digestive Tract**. It is complete.
7. **Gill Slits.** These are narrow openings in the pharynx. When gill slits are present, they are one to several pairs. Gill slits are *dorsal in position*. They are lateral in chordates.
8. **Respiration.** Respiration takes place through branchial portion of pharynx bearing gill slits.
9. **Blood Vascular System**. It is "*open type*", usually with a contractile heart vesicle and two longitudinal vessels, one dorsal and one ventral, interconnected by lateral vessels and sinuses. Blood is colourless.
10. **Excretory organ**. It is a single *proboscis gland* or **glomerulus** situated in the proboscis.

11. **Nervous system**. It is primitive, consisting mainly of an intraepidermal nerve plexus. *Balanaoglossus* has both dorsal nerve cord and ventral nerve cord.

12. **Sense organs**. Sensory cells of the epidermis act as sense organs.

13. **Reproduction**. It is mostly sexual. Sexes are separate or united. Gonads are one to several pairs. Fertilization is external.

14. **Development**. Except in some forms development is mostly indirect through a free swimming **tornaria larva**. Examples: *Balanoglossus*, *Saccoglossus*, *Cephalodiscus* and *Rhabdopleura*.

***Balanoglossus*— The Ancorn or Tongue Worm**. It is a marine animal which lives in U-shaped burrows in the bottom sand. It feeds on organic matter ingested along with sand. It is unisexual. Fertilization is external. Life cycle includes a tornaria larva. Power of regeneration is well marked.

It is worm like animal. The body is divisible into three regions. (i) **Proboscis.** It appears as a tongue-like projection, hence the name "tongue worm". (ii) **Collar.** It is the muscular region which bears **mouth** ventrally below the proboscis stalk. (iii) **Trunk.** It is divisible into three regions (a) The anerior **branchiogenital region** which has gill pores and gonads. The lateral regions containing the gonads are thin and flat and form **genital wings**. (b) The middle **hepatic region** is marked externally with irregular elevations due to sacculations formed by projecting **hepatic caeca** of the intestine. (c) The posterior **abdominal region** gradually tapers posteriorly and bears a terminal **anus**.

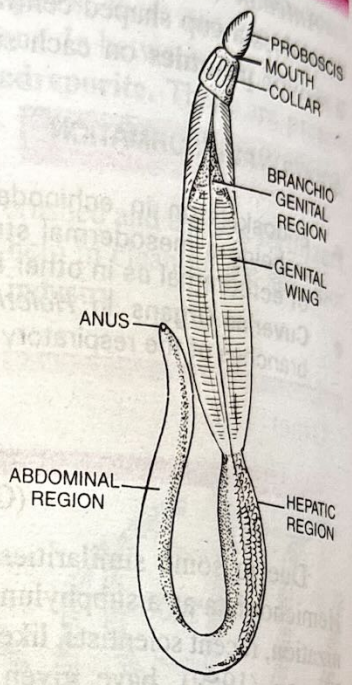


Fig. 4.42. *Balanoglossus.*

Asexual Reproduction in Animals

1. **Binary fission**. Binary fission is the division of the parent animal into two nearly equal sized daughter individuals. It occurs in *Planaria.*

2. **Budding**. An outgrowth called bud appears due to multiplication of cells in the ectodermal layer. The bud grows in size. It is pinched off from the parent organism and establishes itself. Budding is common in *Hydra* and sponges.

3. **Fragmentation**. The body of the parent may break into some pieces. Each piece develops into a whole animal. It is called fragmentation. It occurs in *Planaria* and Sponges.

4. **Gemmule Formation**. In the fresh water sponge (*e.g., Spongilla*) and a few marine sponge buds are formed within the parent's body. They are called **gemmules** (= internal buds). Gemmules come out of the sponge. The cells (**archaeocytes**) of gemmule form a sponge.

5. **Strobilation**. During development, the **gastrula** changes to the **planula** (larva) in *Aurelia* (a jelly fish). The planula forms another larva, the **scyphistoma**. In winter and spring, the scyphistoma undergoes a process of **transverse fission** to form a number of **ephyrae** (larvae) so that the scyphistoma assumes the appearance of a pile of saucers. The division of the scyphistoma larva of *Aurelia* into a number of ephyrae larvae by a series of transverse fissions is called **strobilation**. The ephyrae are detached and feed and grow. In due course of time the ephyrae metamorphose into jelly-fishes. Strobilation also occurs in the neck of *Taenia.*